Engineering Record

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Free Tolls at Panama

FREE tolls for American coastwise shipping going through the Panama Canal is an economic question which, because intimately connected with the greatest engineering achievement of modern times, has a peculiar interest for engineers. The Engineering Record believes that on broad economic grounds there was no excuse for the enactment of the free-tolls provision. The gain in establishing a connection between the Atlantic and the Pacific, 4300 miles to the north of Magellan, is enormous compared to the toll that will be levied. Moreover, the exemption of American shipping was a clear violation of the fundamental law that classes particularly benefited by an improvement should pay for the service. It was a subsidy under a thin disguise—a policy which past legislative history has shown is not popular in the United States. When investment returns in this country drop generally to the 5 per cent level of dividends expected from the ownership of merchant vessels, then, and not until then, is there much likelihood of the development of an American merchant marine.

Engineers' Tribute to Goethals

THREE medals were presented to Colonel Goethals last week in recognition of his services at Panama. The National Geographic Society, the Civic Forum and the National Institute of Social Science were the agencies through which appreciation of his achievements was expressed. Still further recognition, however, should and will come through promotion to the highest rank in the army and, very likely, the thanks of Congress. It is notable, however, that no recognition was given in these meetings to the engineer. The lawyer, the educator, the Government official and the public-spirited citizen were in the limelight. Engineers should now unite in showing their appreciation of the Panama achievement and its guiding genius. They, of all citizens, most keenly realize what he has accomplished. To the layman the task was merely stupendous. The engineer, on the other hand, understanding its details of organization, its problems of design and construction, can measure the work; comparison with standards from his own experience enable him to evaluate the task. It would be fitting and graceful if the national engineering societies should undertake a suitable testimonial meeting, inviting to it, also, official representatives of the great engineering societies of other nations. Colonel Goethals has been invited to act as presiding officer of the International Engineering Congress, which will meet in San Francisco next year, and has accepted the invitation. That would be an appropriate time for such a tribute, and it is hoped that the national engineering societies will avail themselves of the opportunity.

Survey of Concrete Materials

FOLLOWING the action taken at the National Conference on Concrete Road Building at Chicago last month the secretary of the conference has sent to the Governors and the presiding officers of the Legislatures of all States, as well as to the State university presidents, State geologists and directors of engineering experiment stations, copies of the resolution urging that the States, through proper agencies, make examinations of the materials within their boundaries appropriate for use in concrete. This is a matter in which local engineering societies can help. Concrete is now used so extensively that the location of suitable supplies of materials and their development are on a par with the intelligent investigation of any other natural resource or the encouragement and assistance given in all States to farming. It will be difficult to convey this idea to legislators, but action on the part of local engineering societies will do more to emphasize the importance of the proposal than the appeal of the road conference. Many of the States through their geological surveys and engineering colleges are ready to do the work as soon as the additional funds for more men, traveling expenses and publication of reports are made available. Engineers should do their part, and through the local engineering societies where they exist.

Railroad Management

MR. THORNTON'S appointment as general manager of the Great Eastern Railway has, as was to be expected, brought forth comment from the British engineering press. The appointment itself might have called only for passing notice, but the remarks of the chairman of the board, Lord Claud Hamilton, reflecting upon the capacity of English railway officials, brought forward a matter that could not well be ignored. "Engineering," in its issue of Feb. 20, discusses the subject in a two-column editorial that sets forth views which, to this journal, seem entirely sound. The British journal denies that there is a dearth of competent railway men in England, and points, in substantiation of its position, to the frequency with which officials are called abroad to handle railroad properties, especially in South America. The editorial then asks pertinently: "Why do not the railways keep them [these competent men who go abroad], or insure that they shall have others as good available in case of need?" The Great Eastern's predicament, it holds, is a reflection on the management of that road, and not upon the English railway profession as a whole. Replying to Lord Hamilton's query why competent young men, if there be such in the service, do not *come* forward, "Engineering" wisely says: "We may point out that this is not the duty of a subordinate. Rather it is the duty of their superiors to *bring* the proper men to the front. It should be their continual care that a constant supply of suitable men is in training, and if a dearth actually occurs on an important railway it can only be due to errors in previous management or in the policy of the directorate." This is food for reflection not only for railway managers in England but for Americans as well, no matter in what industrial, public-service or commercial activity they may be engaged. To the American railway managers particularly should its significance be apparent, for if the signs are read rightly there is need for change in handling, in the engineering department at least, the many promising "cubs" who yearly come to the roads only to leave in disgust within the first year. Much valuable timber is being thus lost to the railroads. Can the loss be stopped?

Two Road Conventions Again

ANNOUNCEMENT has been made that the negotiations of the American Highway Association and the American Road Builders' Association looking toward the holding of only one road convention or congress this year have failed of success. The former association will go to Atlanta and the latter to Chicago. Highway engineers and contractors, unless strongly partisan, will turn a deaf ear to any explanations of the failure of the two associations to get together. They wanted a joint meeting—not excuses. They cannot be blamed if they carry out the threat made by many last year that they would attend but one meeting. Undoubtedly both conventions will suffer. Convenience and partisanship will both tend to determine to which of the conventions highway engineers and contractors shall go. They will not let senseless rivalry longer rob them of time and money by going to two meetings. Before the convention of the American Road Builders' Association adjourned in Philadelphia last December the American Highway Association had fixed the place for its next convention. Nevertheless, spurred on by the memory of two meetings last fall, the delegates passed a resolution favoring a joint meeting. In the negotiations which followed, the American Highway Association was willing to let the Road Builders' Association set the date of the meeting and to name the principal officer of the joint congress—the president. The place of the convention, however, was settled—Atlanta—on account of contracts which had been entered into. The directors of the Road Builders' Association declined to go to Atlanta and refused the proposal of the American Highway Association. In so doing, the Engineering Record believes, the Road Builders' Association made a serious mistake. The plea has been made that the exhibitors will not go to Atlanta. That will not hold water, for sixty out of one hundred and two exhibitors at Detroit signed the Atlanta petition, and of those approached only one refused to sign. Forty-one were not interviewed. While the Road Builders' Association, in this journal's opinion, made a mistake in not accepting the Highway Association's proposal, the latter body is not above criticism. Its directors knew of the Philadelphia meeting and should have realized that by settling on Atlanta the negotiations looking toward the joint congress would be made more difficult. It is quite certain that the attendance at both conventions next fall will be less than that of last year. That may help to bring about the single meeting for which there is so great a demand.

Heavy Steel Bridge Fabrication

BRIDGE construction has made notable progress in the United States in the last five years, due to the erection of a number of long-span railroad bridges. The changes made affect not only the materials and designs, but also the fabrication. Among the important structures which stimulated this progress were the first Quebec Bridge, the Beaver and Queensboro bridges and the second Quebec Bridge.

In the second Quebec Bridge, the latest and longest great span to be put under construction, the great magnitude and cost of the superstructure demanded special equipment and methods for the fabrication of its members. The plans for the shop, which will handle about 60,000 tons of material for this bridge alone, were made and revised by practical specialists, familiar with the difficulties of fabricating unusually large steel structures.

Instead of utilizing, supplementing or improving an existing plant, an entirely new million-dollar shop was erected and equipped with the fabrication of this bridge particularly in mind. It has been especially arranged for a normal output of 2000 tons per month, consisting of very heavy members of the highest class construction and extremely accurate finish. The continuous progress of the members, without interruption or congestion, from the state of raw material to finished shipping units, was given particular attention. The amount of equipment for handling the material in process is particularly ample, as is also the supply of standard and special tools, thus offering a very flexible system for the execution of all the important construction operations. Although built for the specific purpose of fabricating this bridge, its cost is not chargeable to this contract alone, for after the completion of the Quebec Bridge it will be available for future bridge work of great magnitude, for which it is probably better equipped than any other plant.

Some of the special machine tools of unusual capacity are described on page 300. They are notable not only for the large dimensions of the pieces on which they will be used but also for the accuracy with which they can finish very large surfaces.

The construction and operation of such a shop are important steps in civil-engineering progress and will tend materially, though indirectly, to improve the quality of workmanship in large steel structures.

Preparing for Commission-Manager Government—A Warning

ATTENTION was called in these columns last week to the remarks by Henry M. Waite, city manager of Dayton, on the commission-manager form of municipal government. The idea is a most attractive one and the inquiries coming to Mr. Waite's desk indicate widespread interest and the likelihood of many adoptions of the plan in the near future. There are, however, certain warnings that should be issued. There is danger of too great haste—of rushing in before conditions are ripe for the establishment of the new order.

As a basis for the new government there must be an impartial and scientific investigation of the existing government. This must extend to every department. Not only will it reveal the good and bad features, and furnish statistical information for comparing the new with the old administration, but will give the city manager reliable figures on which to base his budget and guide himself as to the city's needs. If such an investigation is not made, reliance must be placed on the word of holdovers, who, it can be safely assumed in most cases, are inimical to the new order. Not only will their attitude be a source of danger to the city-manager plan, but the inefficiency of the average municipal accounting scheme and the absence of records as to the performance and efficiency of employees make it absolutely impossible, even when the intentions of the holdovers are of the best, to give the new incumbent figures of any value. The new administration, struggling as it will be, even under the best of conditions, with an untried machine, will be still further handicapped by the necessity of guessing at figures, which are at the foundation of a business administration. That would be an anomalous condition, for the commission-manager form is an effort to run a city as one would a business, and that business is headed for the rocks which has not satisfactory figures on its past operations.

In Dayton, fortunately, a municipal research bureau had been at work for some years before the new form of government was inaugurated. Its work, Mr. Waite testifies, has been invaluable. In fact, he has gone so far as to intimate that without it they would be hopelessly at sea, instead of proceeding, as they now are, with confidence in the basis for their decisions.

This is a most important matter and Mr. Waite is hammering it home whenever the opportunity offers, and especially in his replies to cities and civic bodies which are asking for information with a view of following in Dayton's footsteps. Engineers can and should help to spread the warning and counsel conservative haste lest the commission-manager plan, so full of hope for American municipal government, be given a setback due to failures caused primarily by insufficient preparation for the new order.

Engineering Competitions

THE council of the Institution of Civil Engineers has directed a letter to the members condemning the practice of municipalities inviting engineers "to submit in competition with others their terms for preparing plans and proposals for certain engineering schemes, accompanied then or perhaps at a later stage by estimates of the cost of the works proposed." The Engineering Record takes it that the council condemns not only competition as to the "terms" upon which work will be done but also competition as to design. The council believes that "such a proceeding is very undesirable in the best interests of the public authorities themselves and is derogatory to the engineering profession.

With these views engineers in the United States will be in hearty agreement, even though, with the temper of many public officials, such competitions will be a necessary evil for some time to come. Recent experiences, however, particularly in steel and concrete bridge competitions, have taught engineers that participation in unrestricted competitions, especially when conducted by officials none too competent, is too disagreeable an experience to be often repeated. The only valid excuse for a competition is that it may bring forward a meritorious design from some young engineer, so little known that he could not gain a hearing if the engineer were to be selected in the ordinary way—by an examination of his record and work on the part of the employing officials.

As to objections, readers of the Engineering Record can cite so many that their enumeration here would be superfluous. Their costliness to competitors, the likelihood of incompetent authorities accepting the design of an unqualified engineer merely on appearance or low cost, and the plagiarism of designs are three of the most important objections. Moreover, as to certain works requiring most careful study—such as an extensive sewerage system or a water-supply scheme—competitions should be out of the question, and are rare in the United States. Only when the conditions are few, as in the case of a bridge, are they feasible. In the case of monumental works there is something to be said in extenuation of competitions, but even then there should be limitations as to entry and some reward even to the losers for the time they have spent. Reputable engineers would prefer to be employed on their merits, and sooner or later public authorities must learn that the protection of the public interest demands that they shoulder the responsibility of selecting engineers fully competent to carry out the works in hand, without resorting to the "survival of the fittest" scheme, which fails often to indicate the "fittest."

Free Water Cleanliness

TO encourage cleanliness, furnishing of free water to bathing establishments has been suggested in Chicago. As most of the proposed recipients—hotel baths, physical-culture schools, athletic clubs and natatoriums—charge a substantial fee for service, the argument has no more weight than the old cry against the use of meters on sanitary grounds.

Water furnished without charge to charitable, religious, educational and public institutions in Chicago last year was valued at more than $300,000—about 4½ per cent of the city's total revenue from paying water consumers. Rightly, in the opinion of this journal, the officials have opposed the former grant to the Wanderers and Cricket Club on the ground that no provision exists for such grants in the waterworks charter. Free water is dispensed on council orders, and now on the list are 755 municipal buildings, 2306 religious, educational and charitable premises and 88 State and county users. The State institutions at Dunning were added last year to the burden to the extent of $29,000, and a university succeeded in getting on the free list by carrying the matter to the State Supreme Court. Dunning formerly was on the list until it was taken over by the State. Last fall, however, a new arrangement was made for a maximum of 250,000 gal. per day, equivalent to 100 gal. per capita. For all in excess of this amount—and $3000 has accrued since last September—the institution must pay.

While the gross injustice of supplying water free to any one needs no argument among waterworks officials, laymen need constantly to be reminded that no good reason, from the business standpoint, exists for supplying free water, and if the privilege is granted, those so favored should use diligent care in conserving the supply by the early repair of leaky fixtures. Every grant should be limited to a maximum quantity, above which the city should have the right to collect for excess service, as in the Dunning case. In no other way can a correct accounting be made or any check be had on the undue waste of water. In Chicago an inspection last summer indicated that 16 per cent of the free-water consumers had leaky fixtures, and it is no uncommon thing to see park sprinklers operating vigorously during rainstorms.

Three years ago Prof. R. B. Wiley presented a mass of free-water statistics at the Indiana Sanitary and Water Supply Association. He showed quite conclusively that the water consumer and the taxpayer are not the same person, and, therefore, that the indirect taxation is unjust to the consumer, who pays more than his share for the support of the municipal government. Perhaps a ruling to abolish free water will not be long in coming in Illinois from the new Public Utility Commission. Water companies at least may hope for this result, as in Wisconsin the railroad commission compels municipally owned plants to collect hydrant rentals and other moneys due from services usually free. It is time every department and all institutions stood on their own bottoms and the waterworks ceased to be made to carry other than their own burdens.

Government Aid for Railroads in the Canadian West

RECENT increases in the amounts for which the Province of British Columbia has guaranteed each mile of the lines now under construction by the Canadian Northern Pacific and the Pacific Great Eastern railways have given rise to no little adverse criticism of the governmental policy which makes this possible. Considerable bitterness has been injected into the controversy by the publication at Ottawa of the report of the Commissioners of Investigation, which charges the waste of $40,000,000 in the construction of the National Transcontinental Railway in eastern Canada. A clear distinction should be made, however, between a road built by the Government and one which receives a subsidy or whose bonds are guaranteed up to a certain amount per mile.

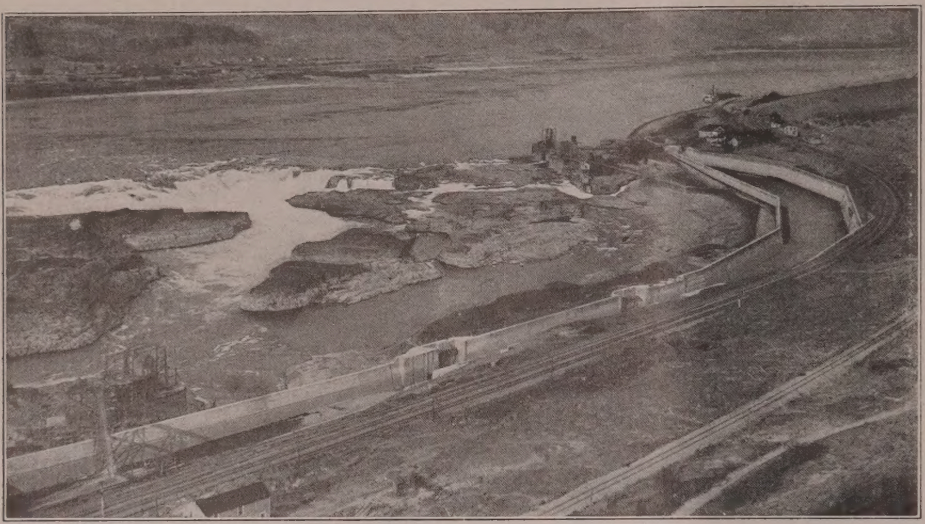
British Columbia, including the backbone of the Rocky Mountains, is so characterized geographically that it cannot develop without costly railroad construction, but since a new line enhances the value of Government lands, opens virgin country, with its attendant promise of undeveloped wealth, and brings new industries into the field, British Columbia, like other provinces in western Canada, has usually been ready to extend aid to the builders when they did not receive it from the Dominion Government.

In the case of the Canadian Pacific a land grant was given for a strip stretching from Port Moody to Savona Ferry, and from here to the summit of the Rockies a cash allowance of $13,000 per mile was made, in addition to 16,000,000 acres of choice prairie land. Although the first cost of the British Columbia division seemed enormous, it is now seen that a much heavier expenditure would have been justified and would have saved the millions of dollars since spent in reducing grades and curvature. Evidence of how the country tapped has developed is given by the branch lines which were built and are still being built in the Kootenay and Boundary districts. The Grand Trunk Pacific Railway in British Columbia, in addition to a cash bonus which is said to amount to $20,000 per mile, is backed by a Government guarantee for 75 per cent of its cost, this cost being somewhere between $103,000 per mile, the estimate of the company's engineers, and $90,000 per mile, the estimate of the Government's engineer. The Canadian Northern has received a cash subsidy of $12,000 per mile and a guarantee of $35,000 per mile, which it is now proposed to increase to $45,000. This increased guarantee has become necessary because the standard of construction has been raised to a point where there is small likelihood of any necessity for a later reconstruction to secure better grades and curvature. This has increased the cost about 30 per cent over the first estimate.

These guarantees simply mean that the credit of the Provincial Government is security for the payment of principal and interest up to the stated amount per mile on the bonds issued to cover the construction costs. Thus the company can secure the money at a lower rate than if borrowing on its own credit.

While the Provincial Government is responsible in this way for a considerable proportion of the railroad mileage within its borders, it is not at all likely, judging by conditions in British Columbia, that a cash outlay will be entailed on any of the lines. Assuming, however, that unexpected conditions forced the Government to take over the British Columbia division of the Canadian Northern, for instance, it may be interesting to consider how costly this turn of affairs would be. In a recent debate Sir Richard McBride, the Provincial Premier, placed the cost of the Canadian Northern line in the province at $70,000 per mile. This is far enough above the total concession to the company (say, $57,000 per mile), so that the Government would be securing at a figure much below construction cost the link which gives a Pacific Coast outlet to a railroad system with 10,000 miles of line, touching a thousand centers of population in a rapidly growing country. This seems to be good security, and if any credence can be placed in reports as to the promise of the virgin territory tapped, the policy of the present administration is a good one and may well, if judiciously applied, be extended to other new lines which will develop the resources of the province.

As for the increased guarantee behind the Pacific Great Eastern Railway, which brings its concession from $35,000 per mile up to $42,000 per mile, there have been notable developments that affect the future of the road since construction was begun. Some of these are the decision to construct the Alaskan railroad system; the activities of the present provincial administration toward securing an all-rail connection between the United States and Alaska, and the recent act providing for a 330-mile extension of the Pacific Great Eastern to tap the Peace River country. These considerations seem to warrant raising the construction standard far beyond that justified by the local business which the line could be expected to do, and it is fortunate that the future importance of the line has become apparent in time to avoid a construction standard which would have been a drawback to operation under the conditions that are now promised.



Entrance to the Dalles-Celilo Canal at Celilo, Oregon

Building the Dalles-Celilo Ship Canal on the Columbia River

Nine-Mile Waterway Approved after the Study of Many Alternative Designs and Constructed by Methods Developed by U. S. Engineers

COLUMBIA RIVER could be considered navigable from the Pacific Ocean to Priest Rapids, Washington, a distance of 407 miles, were it not for the impassable stretch beginning at the foot of Three-Mile Rapids, about 200 miles from the river's mouth, and ending at the Celilo Falls, 9 miles farther up. In this 9-mile stretch are four rapids or falls caused by rock reefs which obstruct the river bed and cause at total fall of 81½ ft. at extreme low water and about 50 ft. during June freshets. The total flow of the river is about 50,000 sec.-ft. at low water and 1,500,000 sec.-ft. at high water.

As early as 1874 surveys were made to determine the best means of passing boats to and from the upper Columbia. A number of more complete surveys were made later, and the tentative plans studied included the following: Full or part length canal on either side of the river, with locks at one or several points, and with or without a dam to raise the river level; a dam to pond the water to the foot of Celilo Falls, requiring a short canal with locks at the dam and another at Celilo; open river improvement to Celilo Falls and a short canal with locks at this point; a boat railway with hydraulic lifts and steam motive power. A continuous 9-mile canal on the Oregon shore extending from above Celilo Falls to the head of Three-Mile Rapids was finally decided upon, and in 1904 a contract was let for open river improvement.

In the plan as finally modified four locks are being located, as shown on one of the drawings, and the canal is being made 65 ft. wide on the bottom, with a low-water depth of 8 ft. The water supply is taken from the pool above Celilo Falls and after passing the first lock near the intake enters a 2¾-mile stretch terminated by the second lock at Ten-Mile Rapids, in which there is a 5-ft. drop at high water. This lock is not used during seasons of low water. Below this a 3½-mile stretch of the canal leads to the lock at Five-Mile Rapids with its drop of 12 ft., and this in turn is followed by a 1½-mile stretch ending in the tandem locks with a drop of 35 ft. each, or 70 ft. at low water, and which open into the main river channel at Big Eddy.

LOCATION OF LOCK

The original plan called for a lock in solid rock close to the canal intake and separated from it by a boat basin formed by a rubble masonry wall on the river side and the natural rock on the shore side. The pervious condition of the wall foundation, however, and an adjacent depression of the surface below the canal bottom level led to the decision to fill the depression up to grade with rock, gravel and sand and cross this with a concrete-lined aqueduct. In order to avoid the upward pressure on the floor of this aqueduct the lock was located in the rock of the downstream end of the depression, so that the water in the aqueduct would at all times have the same level as the upper river.

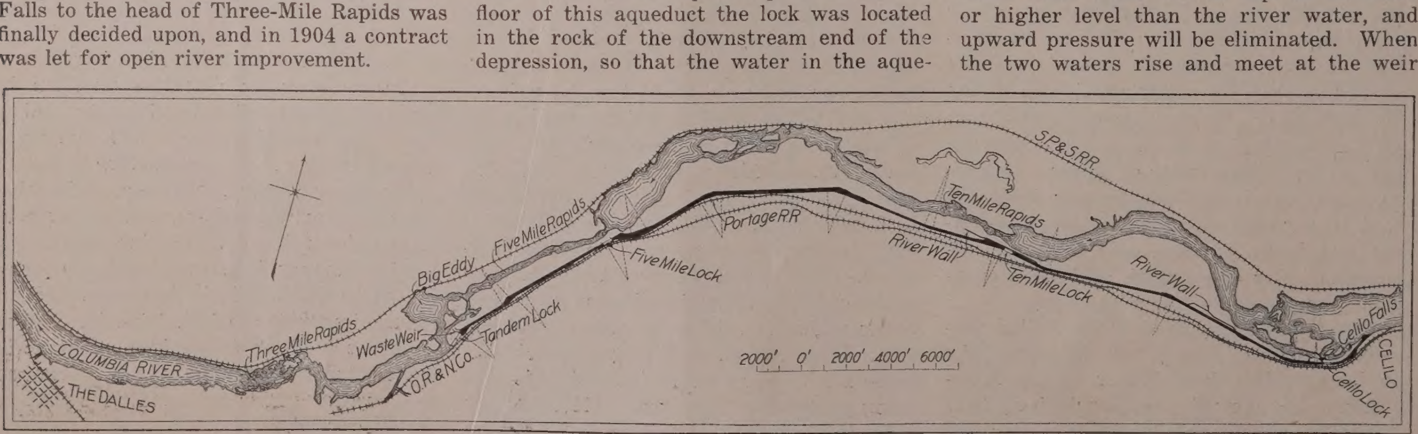
The plan for a gravity wall for the canal trunk in sand and gravel has also been abandoned on account of the expensive subfoundations required, and the canal is being formed by raising embankments above the natural ground surface and covering the waterway with a 12-in. reinforced-concrete lining extending up to a level 2 ft. above the limiting stage. In pervious ground the canal prism is to have side slopes of 1 to 2. The cost of the concrete-lined embankments is only a fraction of the cost of gravity walls and foundations, and the cost of placing the earth in the embankments is negligible because material taken from excavations is used. Besides, probably more than half the material used for embankments would have been required for backfilling the gravity walls.

REGULATING WATER LEVEL IN CANAL

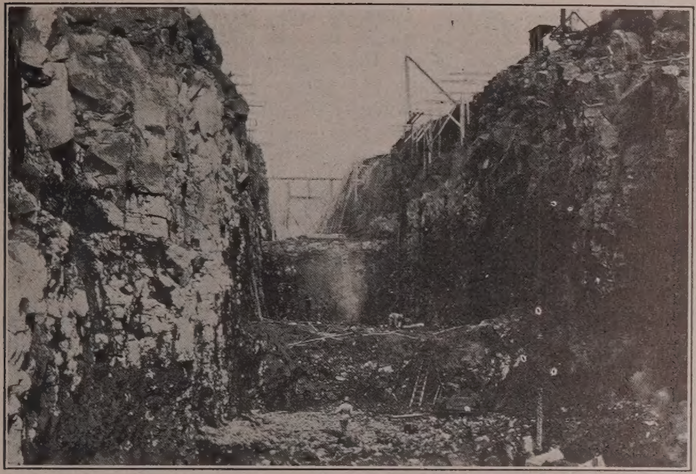
When the survey was made for the canal as originally designed the profile of the water surface from Celilo to Big Eddy at the limiting stage was determined during a falling river. Later investigation showed that the water surface between Celilo and the head of Ten-Mile Rapids was about 2 ft. higher during a rising river than during a falling river, while Celilo gage readings remained the same. A satisfactory profile was obtained only after gage readings had extended over a period of several years. Then, in order to regulate the "drowning out" of the canal and the resultant swift currents, openings were left in the canal walls on the river side at such a level that when the river reaches the limiting stage it will begin to flow in and fill the canal before the river level reaches the tops of the walls. These openings will also regulate the extreme height of water in the canal.

For a little more than a mile the canal passes through a gravel deposit with a sand bar at its lower end, which extends to a depth of 80 ft. below canal grade. The original plans for this section provided for gravity side walls and a 12-in. floor of plain concrete, the floor to be protected against upward pressure by means of valves. Later investigations showed, however, that the difference in head would at times be as high as 8 ft. and that the cost of making this floor sufficiently strong would be many times that of constructing a lock at the head of Ten-Mile Rapids.

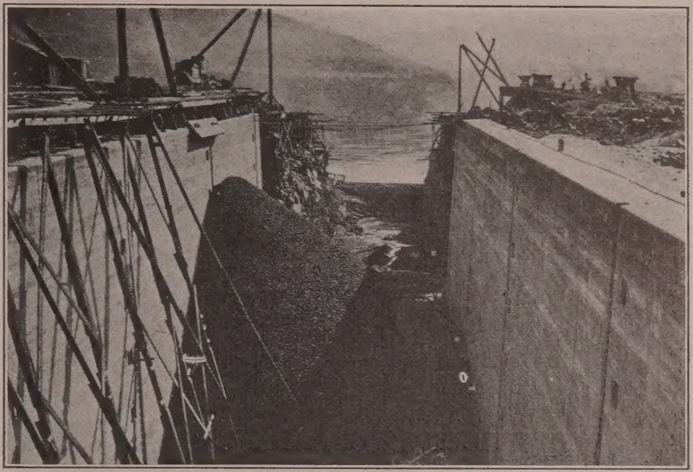
A lock was accordingly designed for this location, and is to be in use whenever the river above Celilo Falls reaches a 5-ft. stage. Thus the water level in the canal below Celilo locks will be kept at the same or higher level than the river water, and upward pressure will be eliminated. When the two waters rise and meet at the weir



Plan Showing Location of Locks in the Dalles-Celilo Canal and Its Relation to the Columbia River



Excavating for Tandem Locks at Big Eddy



Crushed Rock Stored in Upper Tandem Lock

levels, 2 ft. below the tops of the walls, the canal will form a part of the river and will be "drowned out" without damage to walls or embankment.

LOCK DESIGN

The final design of the lock calls for a length of 300 ft. and a 45-ft. width. The lock chambers are excavated in solid rock just large enough to allow for a concrete face wall to cover the rough surface. This lining will have a minimum thickness of 18 in. and a maximum thickness of 3 ft. It is to be anchored to the rock with steel rods and will have a batter of 24 to 1. Drain tile laid within the concrete is to provide escape for any water that might get between the rock and the lining.

COMPARISONS OF QUANTITIES HANDLED BY HIRED LABOR AND BY CONTRACT (CUBIC YARDS)

Material handled	Contract No. 1, extending over 53 months	Contract No. 2, extending over 31 months	Hired labor, 30 months	Total to Jan. 1
Solid excavation	70,836	360,019	513,560	944,415
Sand excavation	9,156	340,261	375,285	724,702
Common excavation	35,644	176,953	268,470	481,067
Masonry	33,338	115,928	27,742	77,018

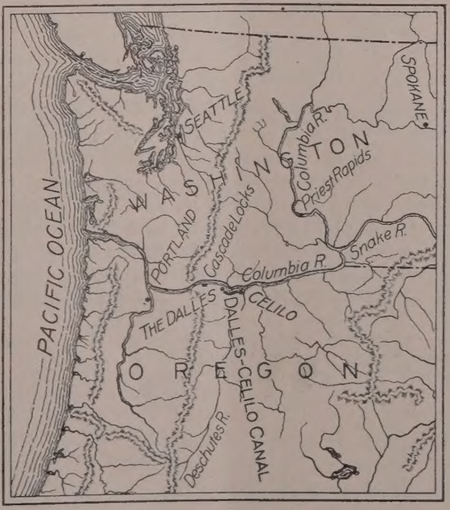
Celilo and Ten-Mile locks will be filled and emptied by the butterfly valves in the lock gates, while the tandem locks at Big Eddy will be provided with 5 x 7-ft. tunnels in the rock, parallel to the lock and connected to it by seven filling ports, each 3 ft. in diameter. Five-Mile lock will be filled by means of a tunnel with six ports through the lift wall, controlled by two 6-ft. cylindrical valves. In unsound rock the tunnels will be made large enough to allow for a concrete lining, but will be unlined in the solid rock, allowance being made for friction by using a larger cross section in the unlined tunnels.

At the canal intake a pair of guard gates with filling valves are provided for shutting out the river when repairs to the canal basin or lock are necessary. The lock and boat basin have a common drainage outlet to the river by means of a tunnel through solid rock.

Eleven pairs of steel gates will be required for the locks, and all of these will be of the double-leaf, mitering type, with a minimum metal thickness of ⅜ in. As the length of the gates is only 27 ft. the girders used in them will have parallel flanges to avoid the extra cost of specials. The depth of the girders was determined for the highest gates, and all were made the same depth to simplify shopwork. In calculating the steel dimensions required a fiber stress of 10,000 lb. per square inch for compression and 12,000 lb. per square inch for tension was used. The bottom girder of all gates was reduced in width to allow the gate to overlap the miter sill so that the weight of the gate is about equal to the upward pressure on the bottom girder.

CONSTRUCTION

Contract Work.—The work of improving Three-Mile Rapids, which was completed by contract in 1906, involved the removal of 64,300 cu. yd. of rock and gave a channel through the rapids 250 ft. wide, having a least water depth of 10 ft. On the canal proper only two contracts were awarded, one in October, 1905, for the construction of a ½-mile length at the intake and another in September, 1908, for 14,000 ft. of trunk canal. Construction under the contract system, however, confined activities to sections of the canal where the work could be completed for a sum within the amount of funds available, so that no unfinished work would be in danger of being left uncompleted and exposed to the river freshets. It was therefore decided to complete the canal work by hired labor, and in July, 1910, forces were organized for beginning excavation on the Big Eddy locks.



Key Map Showing Dalles-Celilo Canal

Organization and Progress.—By April, 1911, headquarters had been established at Big Eddy, and three camps, with buildings completed, were fully equipped and were working a force of about 600 men. The force has varied from time to time, but during November and December, 1913, about 1300 men were employed. The entire work is under the direction of Capt. T. H. Dillon, Corps of Engineers, U. S. A., and F. C. Schubert, assistant engineer. The staff includes two junior engineers, two surveyors or draftsmen, a mechanical draftsman, one chief clerk, one cost-keeping accountant, one stenographer, one head timekeeper, a cement tester and a general storekeeper. A superintendent in charge of each camp and the construction work done by its men reports direct to headquarters, where all accounts are kept and all orders issued.

The success of the system employing hired labor is considered as very satisfactory, besides having the great advantage of permitting changes in the plans without considering the effects these may have upon a contract.

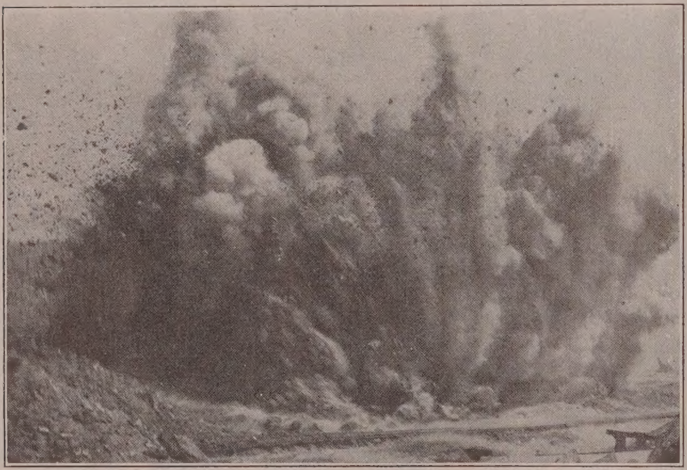
The present accounting system is similar to that used by the U. S. Reclamation Service; every employee and every item of work is given a number, and a careful account is kept of the cost of the work on each item, both material and labor. The latter item is divided into one-quarter-day units, so that a day's work can be apportioned under four different heads if desired. This system necessitates triplicate requisitions for all material and supplies.

STAGE OF THE WORK JAN. 1, 1914

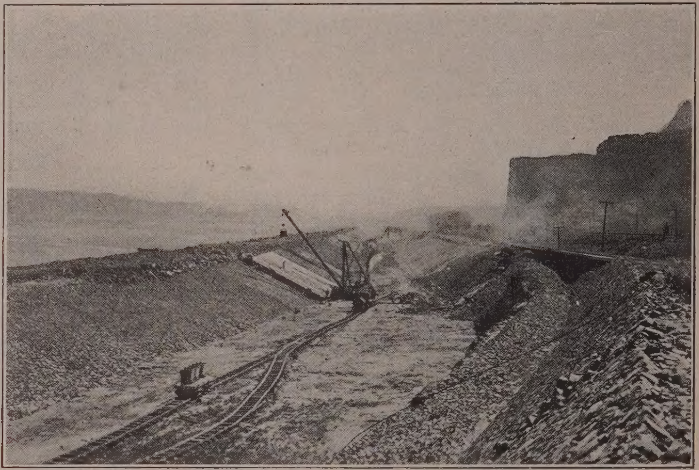
	Per cent completed
Concreting—	
Tandem Locks	70
Five-Mile Locks	60
Ten-Mile Locks	60
Celilo Locks	95
Rubble masonry, Sta. 160-210	80
Rock excavation	80
Sand excavation	practically complete
Gravel excavation	95
Concrete lining	20

For excavating in gravel a 130-ton land dredge has been used to such advantage, it is said, that excavation costs on this material were cut in two. This dredge had a 1½-cu. yd. dipper and a dumping radius of 65 ft., with a lift of 35 ft. above the rail. In using this dredge one-half the canal width would be taken out for a considerable length, then the dredge would go back, the tracks were moved over, and the other half excavated. Embankments were built by dumping direct from the dredge bucket, or, if haulage was necessary, the cars were loaded on top of the embankment, thus avoiding an upgrade haul. Where the gravel was shallow, however, it was found more economical to use a No. 40 Marion shovel which moved on a traction rig.

The rock-crushing and sand-grinding plant installed at Big Eddy is supplied with rock by cars which are loaded by steam shovels and derricks at the excavations, to be delivered to the crushing plant without rehandling. Here it is fed into a No. 7½ McCully crusher and delivered to a conveyor which elevates it to 2½-in. screens over the rock and sand bins. About 80 per cent of the crushed rock will pass through these screens, and the rejections can be fed into a No. 5 Symonds crusher or to two Jeffrey rock pulverizers. About 70 per cent of the material from the pulverizers will pass a ¼-in. screen and the remainder can be put through crushing rolls if desired. With this equipment a crew of 12 men can crush about 300 cu. yd. of rock in eight hours at an approximate cost of 60 cents per cubic yard. The yardage cost, however, has been found to vary considerably, according to the amount of rock which is crushed daily, and with the quantity of concrete placed daily, for when the sand bins are filled the sand-crushing plant shuts down temporarily.



3000-Yard Blast; 30 Holes, Each Charged with 100 Pounds



Placing the Reinforced-Concrete Lining

The crushing plant supplies two concrete-mixing stations, one at Big Eddy and another opposite Station 283 on the canal line. Stations are 100 ft. apart, the numbering beginning at Big Eddy. At Big Eddy a No. 5 Smith mixer supplies concrete to be conveyed as far as 7000 ft. upstream in ¾-cu. yd. bottom-dump buckets on broad-gage trucks. A 1-cu. yd. Ransome mixer operated by steam engine was installed at Station 283 for supplying concrete lining between Stations 250 and 363.

Between Stations 295 and 360 a total of 39,000 cu. yd. of concrete lining is required. This concrete, in order to expedite delivery from the mixer to the work, is being conveyed in a specially designed car provided with twelve ¾-cu. yd. pockets. When the car arrives at the point where concrete lining is being laid the pockets discharge into ¾-cu. yd. bottom-dump buckets, and these are swung by traveling derricks to any point in the trough of the canal. The maximum haulage distance contemplated is about 7700 ft., and the results which have been obtained with this special car are said to have been so satisfactory that more have been ordered. The mix used is chiefly 1:3:6½ and is purposely delivered to the car rather dry in order that it may not settle into the pockets of the car enough to stick. After its trip in the car, which takes about one minute for each 1000 ft., a little water is added to the concrete before it is deposited. The locomotive hauling this car the maximum distance made the round trip in fifteen minutes. The distance grows shorter daily, as about 40 lin. ft. of canal are lined in eight hours.

The 12-in. concrete lining of the canal is reinforced with ⅝-in. Diamond bars, spaced on 12-in. centers each way. The lining is being laid in strips 8 ft. wide, extending across the canal. Alternate strips are laid and the space between them filled when the first blocks have set. This lining is being mixed dry enough to be poured on a 1:2 slope without "running." Between Stations 160 and 210 the slopes have been protected with rock from excavations, and rubble masonry was found to be a more economical lining than riprap placed on the slope and then covered with concrete.

Operation of Canal

Boats will navigate the canal under their own power, and to facilitate the passage of boats bound in opposite directions an electrically operated system of semaphores at the passing basins will be used. It is estimated that the canal will be navigable for at least ten months annually, as during twenty-six years the river has been found to be above the limiting stage on an average of twenty days annually, while the ice blockades do not usually cover a total of more than three weeks. In twenty-six years the river failed to reach the limit of navigation eight times, and exceeded it for the maximum period in 1880, when the flood lasted sixty-six days. It is estimated that about two hours and fifty minutes will be required for passing a steamboat through the canal, the rate of moving being taken at about 4 miles per hour.

Progress of Construction by Hired Labor (Cubic Yards)

Classification	Total quantities (estimated)	Work Done 1910-11	Work Done 1911-12	Fiscal Years 1912-13	Total to June 30, 1913	Work remaining to be done
Solid rock excavation:						
Lock	153,022	65,139	16,584	61,245	142,968	10,054
Canal trunk	753,062	141,738	205,318	101,890	448,946	304,116
Common excavation	482,344	16,821	205,946	93,501	316,268	166,076
	547,937	211,982	74,674	142,686	429,342	118,595
Sand, concrete and rubble masonry	104,758	7,324	15,810	15,423	38,558	66,200
Concrete reinforced	67,290	0	00	290	290	67,000

Additional Appropriations

There yet remains a sum of $425,000 to be appropriated for the completion of the work, and if this is done before the available funds are exhausted it is planned to keep the present full force at work. This would, it is said, complete the canal before January 1, 1915. The opening of the canal to navigation may not materially affect the existing railroad rates to up river points for the reason that since the installation of the State portage railroad to Celilo and the steamers operated by the Open River Association the railroads have several times reduced freight rates to points above The Dalles. In general it is conceded that the effect of the canal will be more in the regulation of freight rates than in diverting commerce to the river.

The foregoing has been compiled from data furnished by F. C. Schubert, M. Am. Soc. C. E.

Denver Votes Bond Issue for James Peak Tunnel

By a vote of 12,708 to 6732 the electorate of Denver has authorized the $3,000,000 bond issue to finance the city's share of the cost of building the so-called Moffat tunnel—the 6-mile bore through James Peak on the route of the Denver & Salt Lake Railroad. The railroad's share of the cost will be approximately $1,500,000. The tunnel to be built is the longest of three investigated last fall for the Moffat Tunnel Commission by J. Vipond Davies, D. W. Brunton and J. Wellington Finch. It will shorten by 23 miles the route from Denver to Salt Lake City and lower the summit by 2510 ft., thereby making possible a new transcontinental line passing directly through Denver. The tunnel will also be large enough to accommodate two 3-ft. water mains and electric transmission lines to meet any possible future needs of the city.

Experiences with Wood-Stave Pipe

Abstract of Paper by Elbert M. Chandler, General Manager of the Burbank Company, Presented January 14 before the Washington Irrigation Institute

CONTINUOUS wood-stave pipe of Washington fir has found a large use in irrigation work in the Northwest for sizes from 2 to 13 ft. in diameter. The pipe are used principally for inverted siphons and discharge pipes of pumping plants. On the Burbank irrigation project in Walla Walla County, Washington, wood-stave pipes were generally employed and the experience in their maintenance formed the subject of a paper presented Jan. 14 to the Washington Irrigation Institute at North Yakima by Elbert M. Chandler, manager of the Burbank Company. An abstract of the paper follows:

For pressures between 20 and 150 ft. there seems to be no better type than wood pipe built of redwood or fir. For pressures greater than 150 ft. no construction meets the requirements better than steel. Under the high heads the spacing of bands for wood-stave pipe becomes so minute that the cost of the pipe equals or exceeds that of the steel, while concrete may be considered as impractical, since the amount of the reinforcement must almost equal the amount in a steel pipe of equal strength, and the concrete shell must possess marked thickness and most careful construction to prevent excessive sweating.

BURIED PIPE DECAYS

A 38-in. continuous stave inverted siphon, 6200 ft. in length, was built in Walla Walla County, Washington, by the predecessors of the Burbank Company six years ago in accordance with what was then considered good practice. The pipe was buried without protective coating on the outside and was kept full of water at all times except when the temperature was very cold. It was drained and refilled after the cold spell. This structure became impaired for future reliable service and a careful examination of it was made in September, 1912.

Near the bottom of the coulee, for a distance of about 300 ft. where the siphon crossed, the ground was very moist, and had been for several years. Here the staves were in a perfect state of preservation. For the remainder of the length the soil was dry volcanic ash, but the wind had left the top part of the pipe exposed directly to the atmosphere so that four or five staves were exposed. These exposed staves were in a perfect state of preservation, while all staves below the ground surface were seriously decayed from the outside, the rot varying from ½ to 1½ in. The interior of the pipe was found to be moist throughout, although the siphon had been emptied several months previously; but in all cases the interior of the staves had not started to decay.

The following conclusions were drawn from these observations: Wood-stave pipe, without a preservative coating, buried in dry volcanic ash soil and not under hydraulic pressure continuously, is subject to rapid decay; its life would be much greater if the staves were exposed directly to the air, and rapid decay probably would not take place in wet volcanic ash soil. As a further observation the extent of the decay reached its worst stages at the ends of the pipe, being most marked for pressures up to 20 ft.

In reconstructing this siphon it was considered essential that the staves be not exposed to the soil. Consequently new staves and tongues were purchased, using the old steel bands and shoes, and the whole was set on cradles 6 ft. apart, giving a clearance for staves of about 2 in. from the ground. These cradles were constructed of 6 x 8-in. Washington fir 4 ft. long, set on edge and milled out to fit the exterior of the pipe. The maximum cut of milling in the center was 3½ in. These cradles cost $22.25 per 1000 ft., b.m., f.o.b. Burbank. They were sawed in 4-ft. lengths and milled at the sawmill, each one costing 35½ cents, or about 6 cents per linear foot of pipe. The pipe has been used during one irrigation season and the cradles have been found to answer the purpose very well. It was questioned whether the cradles would possess sufficient curvature to prevent flattening of the pipe, but no such adverse effects have been observed. Although the life of the cradles may not be very great, they are not expensive or difficult to replace.

WOOD-PRESERVATIVE TREATMENT

Recent observations in connection with telephone poles treated with hot carbolineum have led to the belief that the construction might have been improved by some such treatment. One of the great advantages of having the pipe above the ground is the ease with which leaks may be detected and promptly repaired. The theory of the wood-stave pipe being founded on the fundamental principle that timber always wet never rots, and assuming that the hydraulic pressure from within will fill the pores of the wood with water, it would not appear to be advisable to cover the exterior of the pipe with paint or other protective coating because the wood pores would be sealed from without and the water could not have access for saturation of all the wood fiber.

On the theory that decay of wood is a bacterial process and that the natural environment for the bacteria requires air, moisture and warmth, draining of the pipes during freezing, and colder weather, with refilling promptly afterward, can not seriously increase the rate of decay. The type of construction adopted, therefore, represents the best practice in view of present information, and a life of from twenty to thirty years should be obtained. The Burbank Company constructed several miles of large continuous stave pipe lines a year ago and the same type of construction was used throughout.

MACHINE-BANDED PIPE

The experience with machine-banded wood pipe has been of a different nature. An 18-in. inverted siphon constructed of machine-banded pipe 1200 ft. in length was constructed on the Burbank project six years ago. It was heavily coated with asphalt and buried 2 ft. under the surface in dry volcanic ash soil. The joints were protected by collars 6 in. long, 1⅛ in. thick and held to the pipe by an adjustable band.

During the first four years of its life it was not used and not a drop of water had passed into it. During the fifth year it was filled with water and found to be tight and in good condition; but during the sixth year, which was the 1913 irrigation season, it was used continuously for seven months. The pipe line is still in perfect condition, but the collars are now being replaced, since they had become entirely decayed. These collars showed that they had been coated on the outside with asphalt, but not on the ends. The ends of the pipe sections were found in a good state of preservation. The repair of the pipe is now under way, and in doing it, before attaching the new collars, the ends of the pipe sections are thoroughly coated with a heavy asphaltic paint, the collars added, and the ends thereof coated likewise.

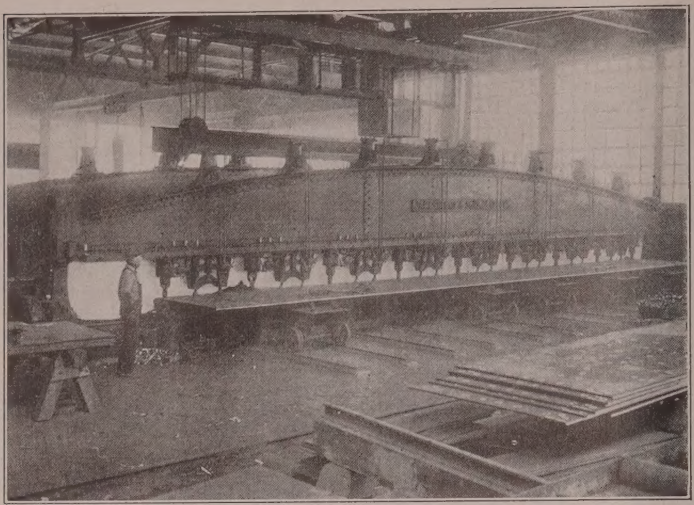
The experience with this machine-banded pipe has shown very clearly that if it is necessary or desirable to bury wood pipe in arid regions every precaution should be taken to see that all exposed parts are coated with a proper preservative. Since the pipe lines in such cases are below the frost line, there is no reason why they cannot be kept full of water throughout the year, in which case the life of the pipe should be very long. In all construction of machine-banded pipe by the Burbank Company this practice has been followed.

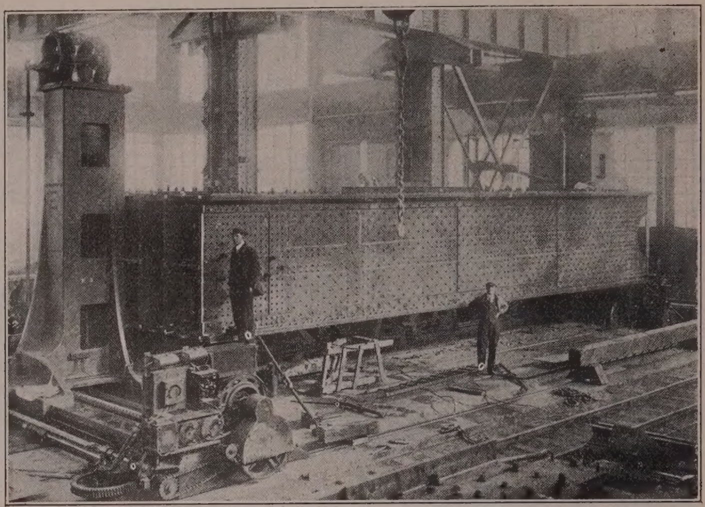
CREOSOTED STAVES

Last year a low-lift canal through a cut of about 14 ft. of volcanic ash was located. To prevent clogging from the drifting soil it was thought expedient to excavate only with 1 to 1 side slopes, throw what surplus fall was available into the section through the cut and install some type of inclosed conduit which would have sufficiently long life to permit of backfilling. Ordinarily a concrete culvert might have been employed, but the work had to be done hurriedly and during cold weather. Ordinary wood-stave pipe would have had a very short life because it would have been laid to the hydraulic gradient and would not have been under pressure. The idea was advanced that if a 50-in. wood-stave pipe was constructed of staves thoroughly creosoted a long life ought to obtain. The pipe manufacturers were asked about it and they agreed as to the advisability of the scheme, but knew of no precedents except a few railway culverts which had proved satisfactory. The penetration of the creosote should be very thorough if applied by a railroad-tie creosoting plant because the staves were only 1⅝ in. thick. Under such circumstances the pores of the staves would be filled completely with creosote so that there would be no opportunity for air or water to secure access to the wood fiber. As a result of theoretical considerations it seems certain that a very long life should obtain.

The pipe line was constructed on the hydraulic gradient, 50 in. in diameter, 1200 ft. long, and ½ in. steel bands spaced 10 in. apart were employed throughout. The additional cost of the creosoting was $23 per 1000 ft. b. m., or approximately 81 cents per linear foot. The entire material cost was $2.15 per linear foot, including creosoting, f.o.b. cars Burbank; the cost of hauling was 7 cents per 100 lb. and the cost of the erection was 25 cents per foot.

TWO billion dollars could be invested with profit in the electrical industry of the United States alone in the next five years—an amount equal to $8,000,000 fresh capital every week, according to a statement by F. A. Vanderlip, president of the National City Bank of New York.


Planing Sheared Edge of Lower-Chord Web Plate


Finished End of 185-Ton Lower-Chord NAL13-14R

Fabrication of Quebec Bridge Members—the Largest and Heaviest Ever Built

How Massive Steel Plates and Shapes for 60,000-Ton Superstructure Are Assembled in Specially Equipped $1,000,000 Shop

FABRICATION now in progress of the 515-ft. anchor arm and the 1800-ft. channel span of the Quebec Bridge across the St. Lawrence River involves the construction of the largest and heaviest bridge members ever built in shops remote from the site. Most of them are of more or less special design, involving powerful machinery and extreme accuracy of construction, and many of them are so long and massive as to reach the limits of transportation.

The 60,000-ton superstructure will be completely fabricated in a shop built at Montreal especially for the purpose at a cost of about $1,000,000 and equipped with special and standard tools of unusual capacity, power, and accuracy that provide for an output of about 2000 tons per month. The general character and important details of some of these members, the method of building them, and the nature and operation of the machine tools are the subject of this article.

The 150 x 650-ft. main shop, which was illustrated in the Engineering Record of June 7, 1913, page 624, has two main longitudinal aisles, one of them devoted to the heavy and the other to the extra-heavy work, which is classified and arranged so that different portions pass through continuously without interrupting other portions, so that any portion of the shop can be operated to full or partial capacity without interfering with any other portion.

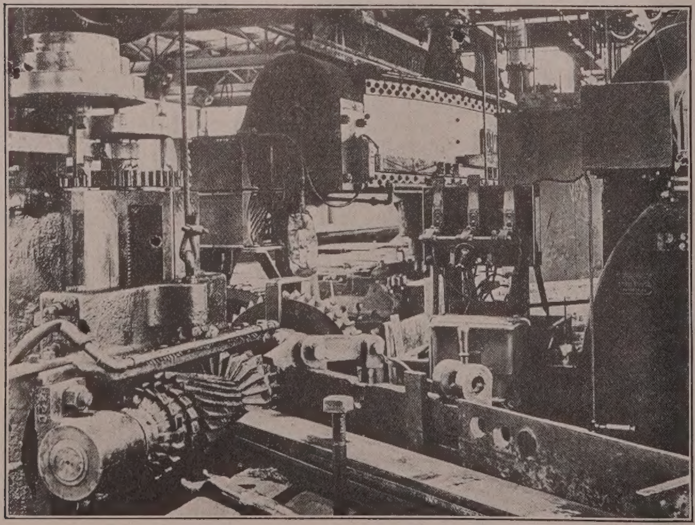
Raw material is delivered at one end of the shop to a storage yard commanded by a long-span traveling crane. It passes continuously through the shops on two full-length longitudinal surface tracks supplemented by 70-ton and 35-ton longitudinal traveling overhead cranes. The sequence of the successive operations and intermediate storage provides for the progress of the work without interruption, congestion, or back motion from one end of the shop to the other, where the finished members are delivered to a large shipping yard, part of which is covered. This yard is commanded by a long-span overhead crane and served by six railroad tracks and shop tracks intersecting the crane runway.

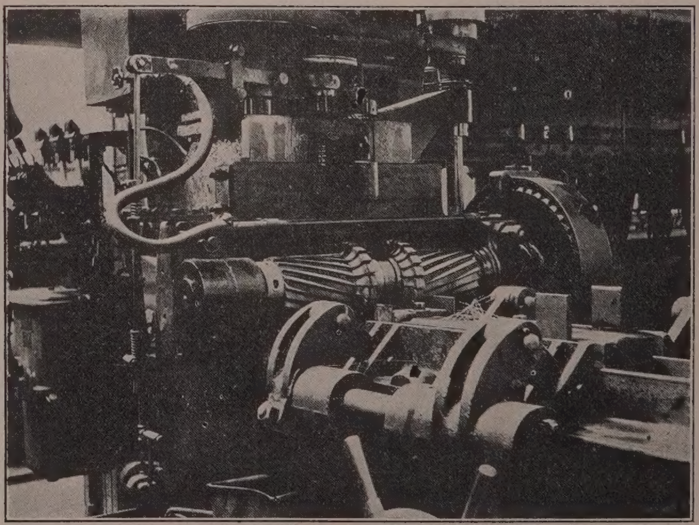
Many of the roof trusses are supported on longitudinal trusses that eliminate most of the interior columns and provide large unobstructed areas of floor space. Most of the machine tools are arranged in rows near and parallel to the longitudinal rows of columns, many of them being provided with roller tables. The wide spaces between them and the surface tracks are largely filled with transverse skids for storing and handling the members, and the machine tools, besides being served by the principal tracks and cranes, have special traveling wall cranes or jib cranes and numerous assembling hoists and trolleys moving on transverse tracks supported by the roof trusses. All of the principal tools are operated by independent electric motors having an aggregate of about 1000 hp.

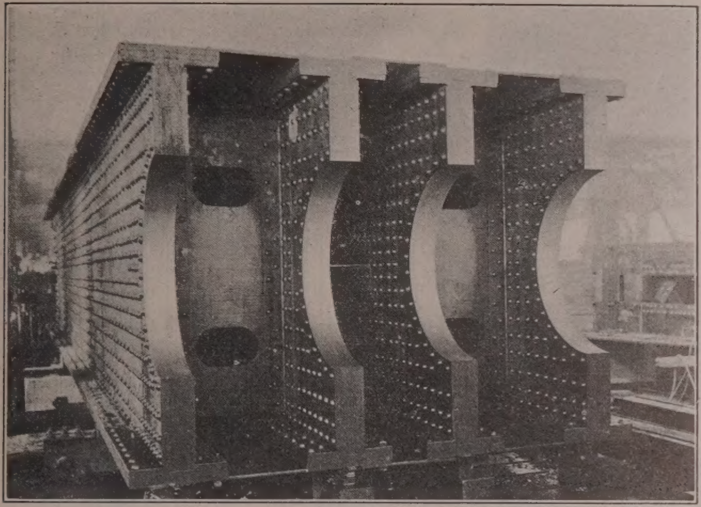
RECEIVING, MARKING AND TRIMMING

Steel plates and shapes, imported largely from the United States, are delivered by the railroad to the receiving yard, where they are handled and stored by a 90-ft. crane traveling on a 500-ft. runway transverse to the axis of the shop, which crosses five standard-gage and service tracks parallel to the shop axis. Steel enters the shop on service tracks, is transferred to skids handled by pneumatic hoists, straightened, sheared, and laid out.

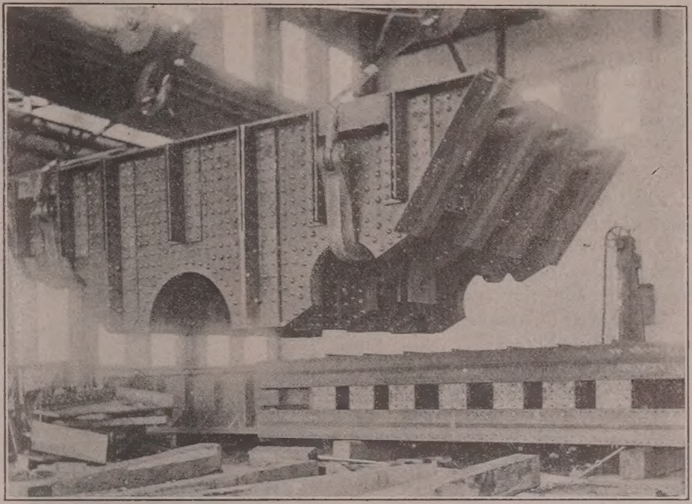
All of the heavy sheared plates have their edges planed in two machines, manufactured by James Bennie & Son, of Glasgow, Scotland, which have a capacity for plates 46 ft. in length. The planed edge of the plate is placed on the bed of the machine, where it is securely clamped by direct


Milling Double-Sheared Ends of Lattice Bars


Milling Ends of Web-Stiffener Angles



Finished End of 185-Ton Lower-Chord Section



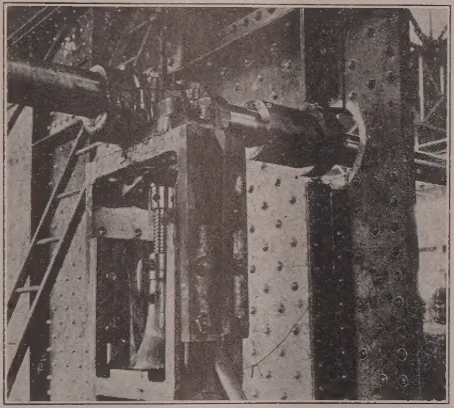
Handling 65-Ton Section of Main-Post Shoe

pneumatic plungers alternating with plungers which operate powerful toggle joints of intermediate double clamps. Except at the planed edge, the plates are supported on the platforms of trucks moving transversely. The cutting tools are operated by a full-length screw drive and are double so as to cut on both advance and return strokes.

Drilling and Reaming

Nearly all of the rivet holes are either drilled from the solid or reamed for 7/8, 1 and 1 1/8-in. rivets. Preliminary holes to enable the plates to be assembled for drilling holes through several thicknesses, and other drilling, are done by a battery of sixteen stationary radial drills manufactured by the Canadian Machinery Company. They have a radius of 7 ft. and are served by overhead assembling hoists moving transverse to the shop axis and handling web plates and other materials on special wooden skids. Besides the stationary drills there are twenty-four movable drills mounted on trucks that are moved from place to place, together with their portable tracks, by the overhead cranes, and are thus available for work on the stationary large members wherever the latter may be located. These machines revolve on a vertical axis, have vertical and radial adjustment, and are driven by variable-speed motors. The machines are moved on their tracks by a ratchet mechanism and are clamped to the rails when in use.

After the compound webs, the built-up channels and beams and other elements of the large compression members have been riveted together they are assembled to form the complete members or sections of them, and many more rivet holes are drilled from the solid or reamed in them, and the rivets are driven. Here the work is divided in two classes—pieces weighing 70 tons or more and pieces weighing less than 70 tons. The rivets are driven largely by pneumatic yoke machines, with capacities up to 100 tons, which are suspended with differential hoists from overhead trolleys and from traveling jib cranes.

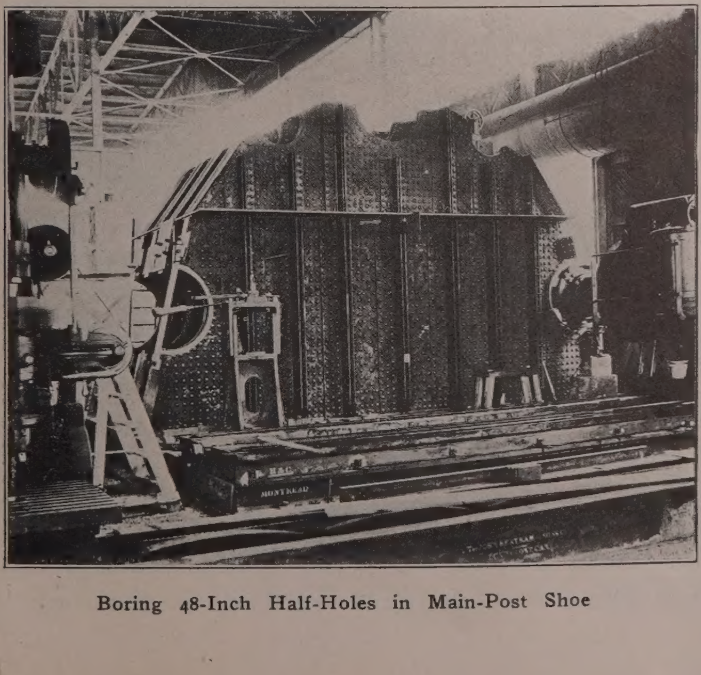


Boring Pinhole in Floorbeam

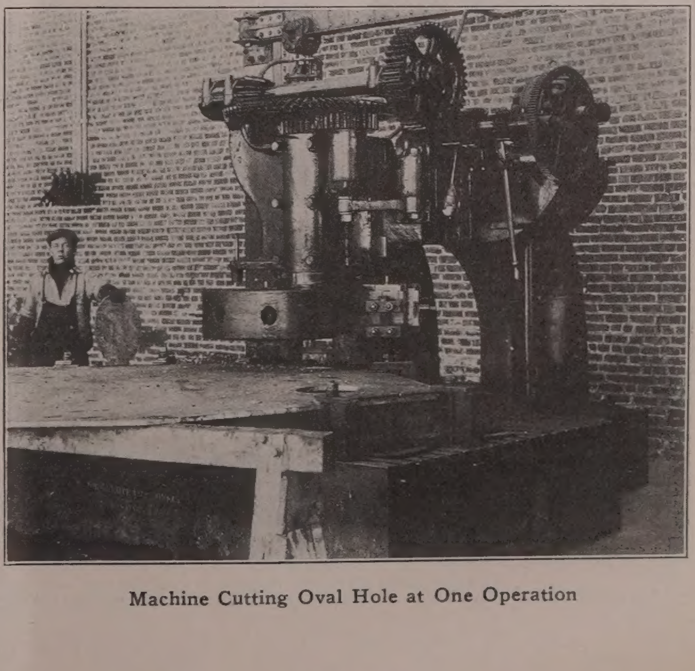
These machines have a reach wide enough to catch the center rivets on all of the chords and girders and a gap sufficient to clear the widest flanges. Rivets which are inaccessible to them are driven by pneumatic hammers. The lower-chord pieces are among the heaviest members handled in the shop and they are lifted and turned by pairs of very heavy vanadium cast-steel hooks connected by double slings made of multiple parts of steel-wire rope, which are used entirely in place of chain slings.

Planing and Boring

The 7½ x 10-ft. ends of the lower-chord members, 42 ft. long, are finished in a duplex vertical and horizontal planing machine with one stationary head and one head movable on a 25 x 100-ft. bed, thus enabling it to be set in different positions and permitting the simultaneous finishing of both ends of all of a set of duplicate members to exactly the same length. They have patent tool holders for cutting in four directions on both direct and return strokes.



Boring 48-Inch Half-Holes in Main-Post Shoe



Machine Cutting Oval Hole at One Operation

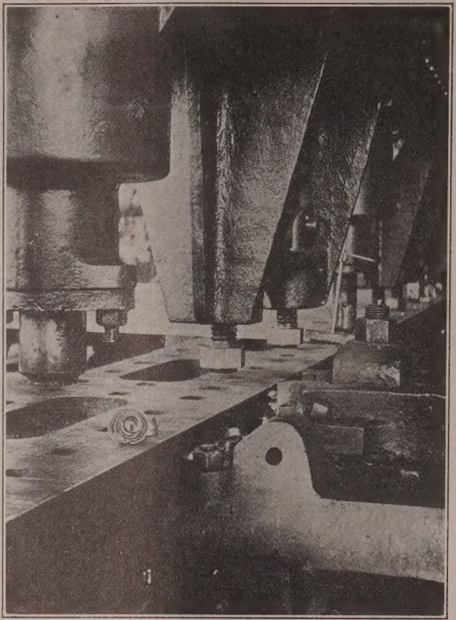
Large pinholes and oval holes for manholes are roughed out of the single plates by a vertical boring mill manufactured by John Bertram & Sons Company, of Dundas, Canada. This machine has a vertical shaft which carries a revolving cutter head with a transverse motion, which enables the tool to describe an ellipse.

The large pinholes up to 4 ft. in diameter are finished in a horizontal boring mill with a transverse motion of 23½ ft. and a vertical motion of 15½ ft., which enables it to finish the five pinholes in the great pedestal without moving the latter.

The riveted shoes for the main vertical posts on the river piers are seated on their heavy sectional cast-steel pedestals, which have their upper and lower surfaces very accurately machined in a planer with a 10 x 30-ft. bed which is installed in a temporary wooden shed in the fitting yard. The shed has a sectional roof any portion of which can be removed by the yard cranes to permit the pedestals to be handled in and out of the machine for storing and loading in the yards.

Miscellaneous Machines

Besides the special machines there is an equipment of standard bridge-shop machine tools, including shears, drills, punches, planers, milling machines and other tools. A double-rotary milling machine has a capacity for finishing moderate-size end bearings, and an 84-in. plate-shearing machine is installed for cutting the largest and heaviest plates. Special milling machines are installed for fitting the ends of vertical web stiffener angles, and horizontal boring machines are provided for the pin bearings in the webs of the floorbeams.

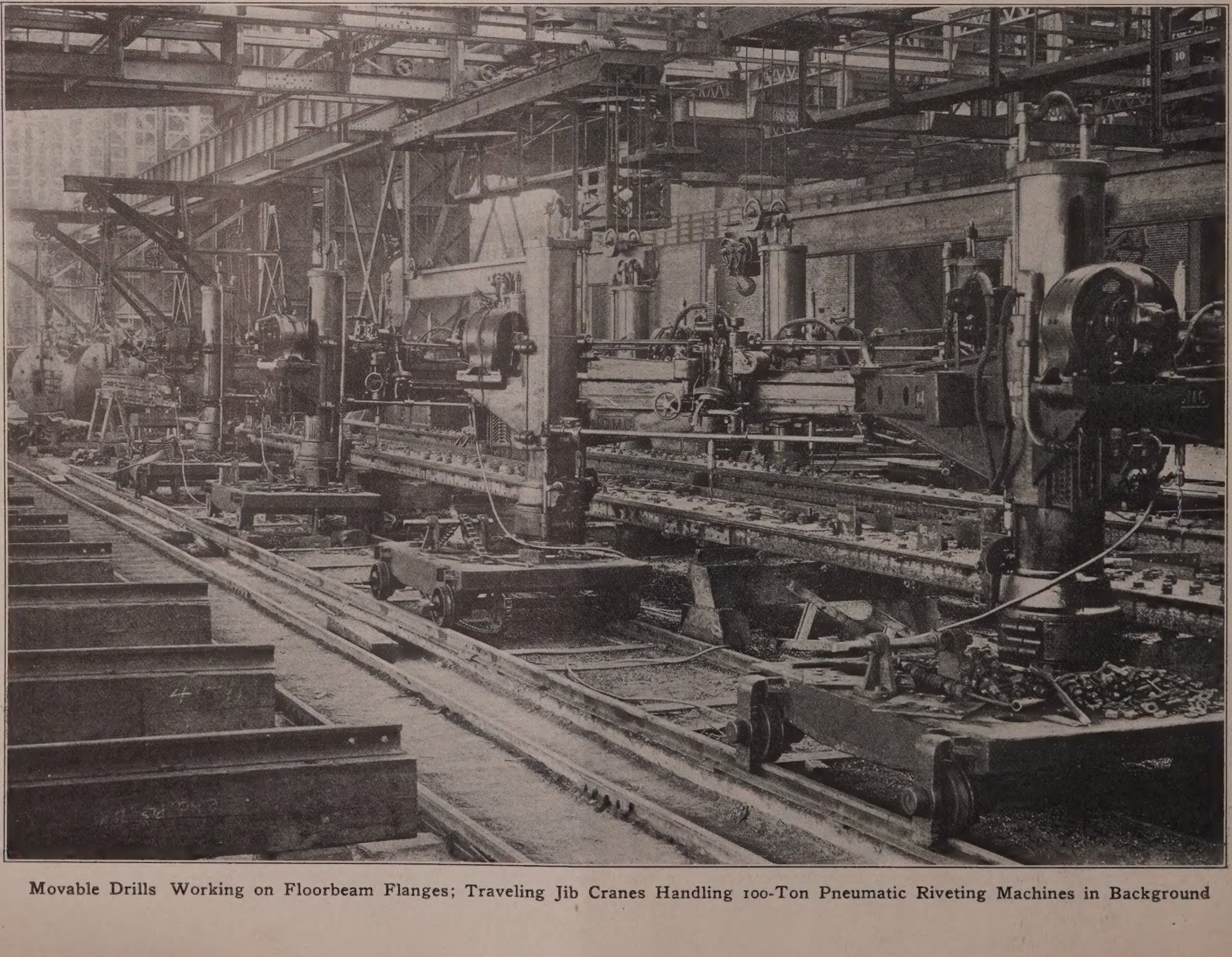


Cutting Tool and Clamps of Edge-Planing Machine

The bottom chords, floorbeams, and other heavy members are riveted by pneumatic yoke riveters suspended from 6-ton jib cranes traveling in both aisles on runways 130 ft. long and having inclined reaction wheels transmitting the bottom thrusts to T-shape tracks in planes about 45 deg. from the vertical. There are two 48-in. and two 24-in. 100-ton Murphy riveters and ten 50 to 100-ton Hanna riveters with 24 to 75-in. throats. The finished floorbeams, weighing as much as 135,000 lb. each, have both single and double webs 10 ft. deep and 90 ft. long. They are shipped from the bridge shop, loaded on three flat cars, securely braced in a vertical plane and supported only at end bearings, which are pivoted to the car platforms and arranged to swivel around curves. A large portion of the floor system has been fabricated and stored at the shops or shipped to the site, and work is in progress on the bottom chords, pedestals and some other members of the anchor arm trusses.

The work is under the direction of the Board of Engineers, of which C. N. Monsarrat is chairman and chief engineer, and is being executed by the St. Lawrence Bridge, Ltd., of which Phelps Johnson is president and W. P. Ladd works manager.

CLASSIFIED estimates for bridge superstructures have been satisfactorily used for the payment of contractors by R. S. Uniacke, bridge engineer of the National Transcontinental Railway, Canada. For a total unit price of $4.23 per 100 lb. of finished superstructure the six estimates allowed are: Delivery of steel, $1.95; fabrication, $1; delivery at site, 20 cents; assembling, 80 cents; riveting, 15 cents, and painting and full completion, 13 cents. The system of reports on record makes the preparation of the estimates rapid and easy and they are found more satisfactory to all concerned than the custom of allowing 20 per cent when erection is commenced and the balance on completion.



Movable Drills Working on Floorbeam Flanges; Traveling Jib Cranes Handling 100-Ton Pneumatic Riveting Machines in Background

One Train Being Hauled by Two Electric-Locomotive Units

Electric Operation of Butte, Anaconda & Pacific Railway

Details of Pioneer Installation in Mountain Electrification—the First Road to Use 2400-Volt Direct Current

THE Butte, Anaconda & Pacific Railway, which has been electrically operated for several months, is a pioneer in mountain electrification in the United States. Electrification in terminal districts and in tunnels has been influenced largely by the considerations of smoke elimination and rapid suburban service, the question of comparative economy being more or less subordinated to these considerations. The Butte, Anaconda & Pacific is believed to be the first steam road operating both freight and passenger trains to electrify its lines purely for reasons of economy. It is also the first road to use the 2400-volt direct current.

Operation

Operating conditions on this road are somewhat unusual. The road is a spur extending from Butte, where connection is had with several trunk lines, to Anaconda, which has no other rail outlet. It is essentially an ore road, and as the ore mines are located near Butte and the smelter at Anaconda there is necessarily a double haul of the product of the mines. The accompanying map shows the situation.

Copper ore is mined near the top of Butte Hill and carried in short trains down the branch line to Rocker, a distance of 4½ miles. Here longer trains are made up and hauled to East Anaconda, where they are subdivided and pulled up to the smelter. The empty cars are returned to the mines, and train loads of copper ingot are taken in the same direction to Butte, where they are turned over to the other roads. There is also considerable local traffic, both passenger and freight, between Butte and Anaconda. The accompanying table gives condensed information as to the freight operations.

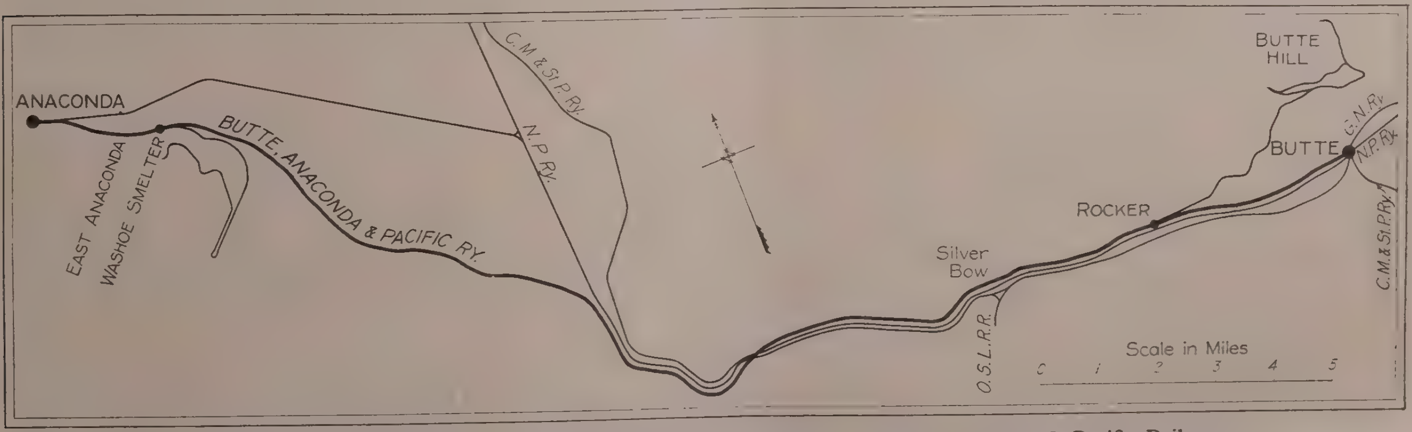
Condensed Information on Freight Movement

	Westbound			Eastbound		
	Butte Hill	Main line	Smelter Hill	Smelter Hill	Main line	Butte Hill
Trailing load in tons	2,000	4,000	1,400	1,000	1,260	650
Number of cars	30	60	20	55	70	35
Number of 80-ton locomotives per train	2	2	2	2	2	2
Approximate grade against load in per cent	2.5	0.3	1.1	1.1	1	2.5
Approximate speed on level tangent track in miles per hour	.....	21	.....	.....	25	.....
Approximate speed on maximum grade	12	16	16	20	16	16
Average trolley voltage	2,200	2,200	2,200	2,200	2,200	2,200
Length of run in miles	4.6	20.1	7	7	20.1	4.6

The first electric locomotives were put into service May 28, 1913, hauling ore cars between East Anaconda and the smelter. During the first seven months of service they made approximately 201,000 miles and hauled about 2,365,000 tons of ore. The main-line trains were first hauled by electric locomotives Oct. 1, 1913, and promptly demonstrated their ability to make better time than was possible with steam locomotives.

Electric energy is obtained from the Great Falls Power Company, whose generating plant is located at Great Falls, Mont., on the Missouri River. This plant has been supplying electric power for the operation of the mines and smelters for some time. It has six hydroelectric units, with a nominal rated capacity of 21,000 kw. The power is transmitted at 102,000 volts to the transformer substation at Butte, a distance of 130 miles, over two separate parallel lines constructed on the same right-of-way. Here it is stepped down to 2,400 volts. An extension of the system transmits power at 60,000 volts to the second transformer station at Anaconda. Although the Butte station forms the center of an extensive power system operated by the Montana Power Company the railway load was taken on without any increase in the high-tension transmission facilities. It is estimated that the additional railway load is approximately 20 per cent of the former load. The overhead construction was specially designed to give the flexibility necessary for the satisfactory operation of the pantograph trolley used on the locomotives. The copper trolley used over all tracks is supported by an eleven-point catenary suspension from a standard steel messenger cable. Both side bracket and cross-span construction are used as required by the local conditions. There is a large amount of special work on account of the many yards and sidings. In one case, where twelve tracks are spanned, the cross-span construction is supported by a third pole between the eighth and ninth tracks.

The locomotives were described in the Current News of the issue of June 7, 1913. There are seventeen locomotives, of which fifteen are for freight and two for passenger service. The freight locomotives are geared for slow speed and operated in pairs for the main-line service. The maximum free running speed is 35 miles per hour. Single units do the switching and spotting of cars at the mines and at the smelter.



Skeleton Map of Main Line, Branches and Foreign Connections of Butte, Anaconda & Pacific Railway

The passenger locomotives are geared for a maximum free running speed of 55 miles per hour, or 45 miles per hour with three passenger cars on straight level track. Curves as sharp as 20 deg. occur on the Butte Hill line, which has an average curvature of from 6 to 10 deg. The locomotives are therefore designed with sufficient flexibility to round a curve of 31 deg. at slow speed.

All apparatus for the electrification of the road was furnished by the General Electric Company, of Schenectady, N. Y.

Broken Water Main Causes Building Collapse at Springfield

Rush of Water below Frost Line Undermines Foundations of Brick Tenement House and Walls Fall

By ELBERT E. LOCHRIDGE
Chief Engineer of Water Department, Springfield, Massachusetts

UNDERMINED by water from a broken main, a brick tenement house at 103 Water Street, Springfield, Mass., collapsed on the morning of March 1. When the new Little River water-supply system entering Springfield from the west was built the distribution system was readjusted by the construction around the city of a circuit of pipe, all 24 in. in diameter or larger. This construction was necessary to reinforce a system designed for bringing water from the easterly side of the city and not adaptable for such distribution from the opposite direction. The portion of this circuit through the business section is a 36-in. cast-iron main through Water Street, which is next and parallel to Main Street on the west, the main business street of the city. Shortly after midnight Sunday morning a large leak was reported on this Water Street main.

DAMAGE DONE

As prompt a response by the men on the night emergency force as weather and snow conditions would permit at this time resulted in the closing of the gates which surrounded this section in one hour and fifty minutes. On the 36-in. line it was necessary to close two 24-in. gates, together with seven side-street connections with this main. The first effect of the flow of water was the forcing of an opening between the main and the cellar of the house at 103 Water Street, which indicated that the water from whatever pipe was affected had passed along underneath the layer of 4½ ft. of frost and frozen ground which covered the street and lot at this point. The distance from the main to the house was about 18 ft. At another season of the year this water would probably have come directly to the surface and resulted in less damage. This flow entering the house cellar quickly undermined the house and the front half collapsed very soon after the break occurred. A little later the crust of frost, together with the hydrant, sidewalk and paving, fell in and a deep hole from the main to what was the center of the house resulted. There were four tenements in the block, two of which collapsed. The tenants escaped without injury, but were unable to save any of their personal property.

The recording gage at the office of the water department, about 150 ft. from the break, recorded a sudden drop from the normal pressure of 144 lb. to 120 lb. at midnight. This latter pressure was maintained on the gage with very little variation until 1.05 a. m., when a second sudden drop to 70 lb. occurred. The pressure remained near this point until 1.50 a. m., when the normal pressure was restored by the closing of the last of the several gates surrounding the point of trouble.

Two hours after the pressure was restored to normal a serious fire occurred in the Park Theater building, and fifteen fire streams were used for more than two hours. Although the section of the circuit at the point of trouble was shut out during this time and until 2 p. m. Sunday, the lowest pressure recorded during the fire was 140 lb., a drop of only 4 lb. below normal, thus demonstrating the efficiency of a circuit for supplying water even though one section of it is disabled.

Building in Springfield Undermined by Water from Broken Main

CAUSE OF BREAK UNKNOWN

The original cause of the break has not as yet been determined, and although workmen have been digging constantly up to the time of this writing, the afternoon of March 4, no trace of the hydrant or any of its connections except at the main have been found and nothing is known of the cause. When the water was pumped from the hole the main was intact and fully supported by earth, and no erosion was manifest on the street side. The openings from the main were an 8-in. bell and a 1-in. corporation within 5 ft. of each other. When the workmen first arrived the hydrant was still in place at the curb line, with no apparent leakage about it.

Suez Canal Improvements

IMPROVEMENT of the present facilities of the Suez Canal, with provision for larger ships, will, it is expected, be completed in 1918-19, according to the Engineering Supplement of the London "Times." The company has power to raise in bonds a sum of $30,000,000.

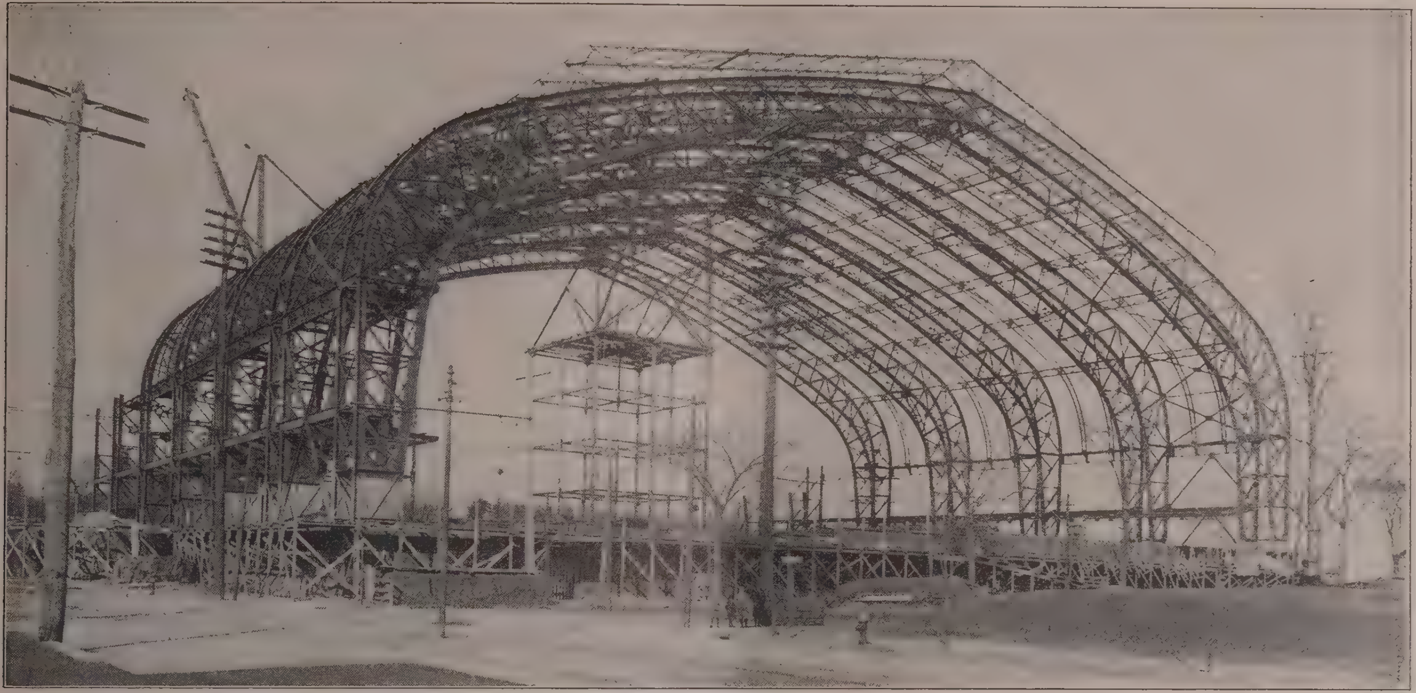
The maximum permissible draft of ships using the canal was 24.4 ft. in 1870; in 1890 ships drawing 25.4 ft. could make the passage; and during the following twenty-four years the increase has been at the average rate of about 1 ft. every six years, thus bringing the maximum draft authorized to 29 ft.

The declared policy of the canal company in regard to the deepening of the canal is to offer a slightly greater depth of water than that available in ports east of Suez. It is claimed that, with the exception of Sydney, there is no Eastern port which at low tide has a greater depth of water than that now provided in the canal throughout the full length of nearly 105 miles.

When the canal was opened in 1869 the width was 72 ft. and the depth about 26 ft. 2 in. In June, 1913, the width at a depth of 32 ft. 8 in. had been increased to a minimum of 147 ft. 6 in. over a length of about 85 miles and to a width of 328 ft. over a distance of about 20 miles. The latest scheme makes provision for a depth of 40 ft. throughout and for a widening up to 196 ft. 8 in. in the south section, and the cutting of an appropriate number of sidings in the north and central sections, where a minimum width of 147 ft. 6 in. is believed to be sufficient for the requirements of the immediate future.

The work of enlarging the capacity of the canal presents no special difficulty on the engineering side. A good deal of sand is occasionally driven into the channel at Port Said during storms, but a remedy for this will be found in the extension of the west breakwater by about 2,700 yd. at a cost of more than $3,000,000. The construction of this extension, which has been in hand for the last two years, is making satisfactory progress. The Suez Roads are being adequately dredged in accordance with an agreement between the Egyptian Government and the company.

To carry out the improvements which have been decided upon the canal company has acquired a powerful dredging plant, which comprises twenty-four dredges of various types, representing more than 16,000 hp and having an extracting capacity of about 8000 cu. m. an hour. Four of the most powerful dredges are allocated to the cleaning and deepening of the channel at Port Said, and the last dredges ordered can work at a depth of 50 ft.



Erecting Fifth Pair of Arch Trusses—Purlins, Bracing, and Monitor Frames Assembled as Travelers Advance

Erecting an Armory Roof to Cover Unobstructed Floor 600 x 300 Feet

Pairs of 289-Foot Arch-Roof Trusses Erected by Two Travelers More Than 90 Feet High on Second Floor of Building

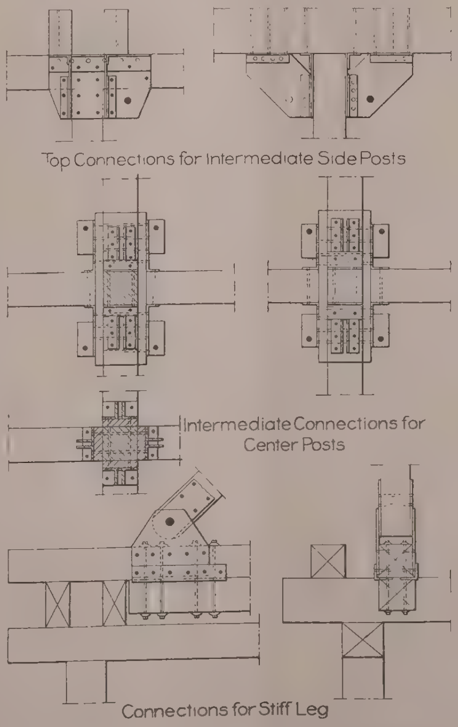
ABOUT 600 ft. long and 300 ft. wide, the drill hall of the armory of the Eighth Artillery District, National Guard, New York, at Kingsbridge Road and Jerome Avenue, Borough of The Bronx, New York City, is unusually large. It is unobstructed by columns and is covered by a roof having fourteen pairs of arch trusses of 288 ft. 10-in. span and 108-ft. rise. Each truss weighs about 200,000 lb. and is shipped in separate pieces, assembled and riveted on the floor and erected in four sections by the travelers. The main features of this armory were described in the Engineering Record of Jan. 24, page 93.

ASSEMBLING TRUSSES

The T-shape cross-sections of each chord are received at the site in four pieces, knocked down, and three built-up truss sections for each semi-truss. The longest section is the top-chord crown piece, about 55 ft. long, weighing 8½ tons. The web members of the trusses weigh as much as ¾ ton each. The end sections of the top and bottom chords for each truss, together with the requisite web members, are assembled, making four-panel sections of the truss about 44 ft. long up to the point where there is a field splice and the vertical top chord becomes tangent to the curved portion of the next inclined section. This portion of the truss weighs about 12 tons and is first erected by one boom of the traveler. The truss is seated on its pedestal and the 8-in. pin is driven and the truss is then braced in position by an inclined shore and guy rope as indicated in the general elevation.

The curved remainder of the semi-truss, weighing about 38 tons and having a chord about 155 ft. long, is assembled on skids on the drill-hall floor, where all of the joints are service-bolted, reamed if necessary and pulled up to contact under heavy stress by steamboat ratchets, after which the field rivets, about 1200 in each semi-roof truss, are driven by pneumatic hammers while the truss remains in a horizontal plane on the skids.

The trusses are spaced alternately 10 ft. and 35 ft. apart, the pairs 10 ft. apart being braced together throughout the full length of their top and bottom chords. After the end vertical sections of the trusses were erected and temporarily braced in position the remaining sections of the two semi-trusses next to the end of the roof were simultaneously erected by the traveler derricks lifting them by slings attached to their top chords at approximately equal distances from the center of gravity. The derricks supported them until the splices at the haunches were service bolted and the 7-in. crown pins were driven.


Top Connections for Intermediate Side Posts
Intermediate Connections for Center Posts
Connections for Stiff Leg

Riveted Connections for Traveler Members

The trussed braces, marked A and B on the diagram, were then securely lashed to the bottom chord of the truss and shores fitted to the top chord, providing stability which enabled the derricks to be released so as to erect the first or end truss, which they held in position until the splice and crown joints were made and until the bracing between the two trusses was assembled. The traveler then retreated one panel, or 45 ft. from its original position, and erected the third and fourth trusses successively in the same manner as described for the second and first trusses. Additional pairs of trusses from end to end of the building were erected in this manner.

RIVETING

Each truss contains a large number of ⅞-in. field rivets in its main connections, exclusive of the rivets in the connections to the lateral bracing and in the bracing between the twin trusses. A pair of trusses is assembled in less than one day by an average force of twenty-five men. The riveting is done with five gangs and occupies about one and a half days. The actual erection of the semi-trusses takes about one-half hour each, including the connection at the crown, and the work advanced at the rate of about eight trusses in one month.

Each of the two duplicate 60 x 60-ft. traveler towers, 91 ft. 8 in. high, has nine vertical posts and three sets of longitudinal and transverse horizontal struts between the sill and top, dividing the height into four stories of about 22 ft. The three three-post bents have caps and sills made of pairs of 8 x 16-in. timbers. The two front corner vertical posts are 14 x 14-in.

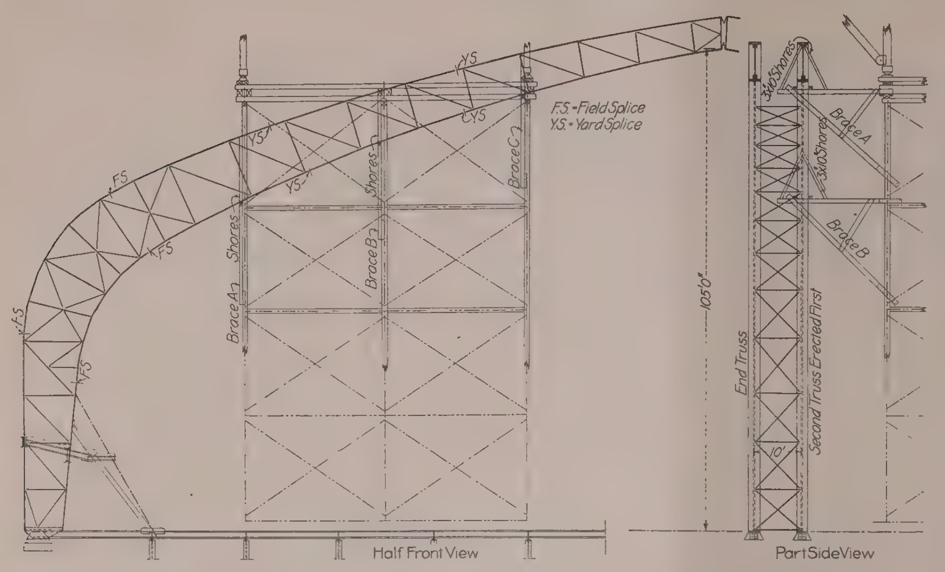


Diagram of Semi-Arch Truss and Traveler Serving Temporarily as Falsework

timbers and all other timber in the vertical posts and horizontal struts is 12 x 12-in. yellow-pine, spliced at all intersections.

All panels in the exterior faces of the traveler and in the horizontal plane of each story are X-braced, with sleeve nut rods in the vertical planes and steel cables in the horizontal planes. The connections are all made with bolted angles and riveted gusset plates, as shown in the details. Each traveler is mounted on nine pairs of double-flange wheels running on three lines of rails 30 ft. apart.

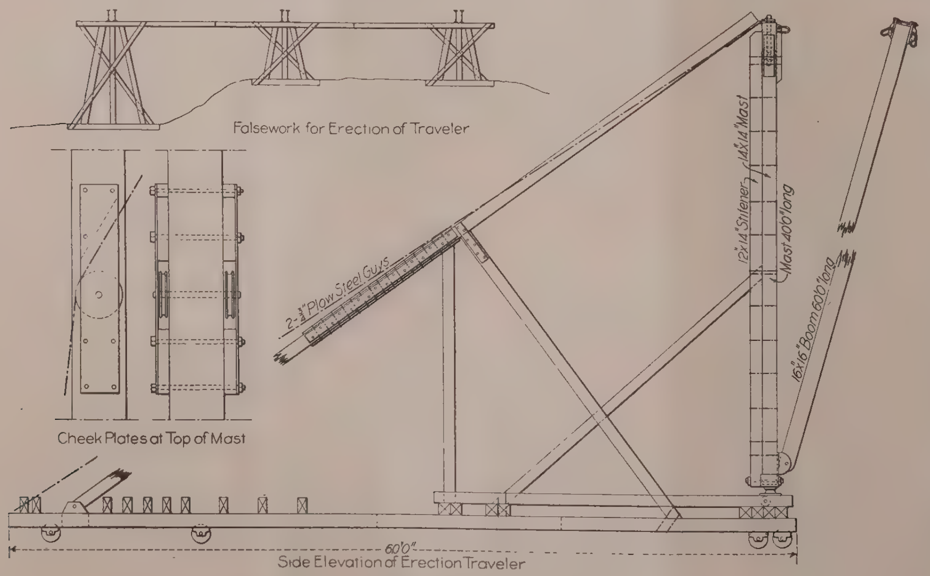
Derricks

On top of each traveler there are mounted two stiffleg wooden derricks with one 60-ft. and one 80-ft. 16 x 16-in. boom having a capacity of 25 tons each. Before the travelers were built these derricks, mounted in pairs on rolling platforms, served as travelers for the erection of the columns and girders under the drill-hall floor. Like the travelers, the derricks are of 12 x 12-in. timber, except the 14 x 14-in. masts reinforced by full length 12 x 14-in. pieces, and the pairs of 8 x 16-in. sill pieces. At the top of the mast the sheaves are set in cheek plate, offset from the mast timber to avoid cutting the latter. The track rails are bolted to 8 x 16-in. timbers laid flatwise and bolted to 20-in. I-beams in the armory floor, to stiffen them laterally.

In order to erect the main travelers before the fill was completed around the front of the building it was necessary to provide falsework for them. This consisted of several framed bents of different character and dimensions, according to the length and height of falsework structure. They each had two batter posts and one or two vertical posts, which, with the caps and sills, were all made of 12 x 12-in. timber and 3 x 10-in. diagonal bracing. The oak caps were made continuous from one bent to the next, and supported pairs of 24-in. I-beams, which braced them transversely.

Quantities and Plant

The armory contains about 7600 tons of structural steel, including about 4000 tons for the roof trusses. Each main traveler contains about 120,000 ft. of timber, board measure, and 15 tons of steel, and the falsework contains 100,000 ft. of timber. The travelers are operated by two Lidgerwood and two Lambert double-drum hoisting engines located in stationary positions on the drill-hall floor. The field rivets are driven by pneumatic hammers operated by air compressed in a Franklin machine located in the yard at the west end of the building.


Falsework for Erection of Traveler
Cheek Plates at Top of Mast
14x14 Mast
12x14 Stiffeners
Mast 40'0" long
2-3/4" Plow Steel Guys
16x16 Boom 60'0" long
60'0"
Side Elevation of Erection Traveler

Traveler Falsework and Erection Derrick Mounted on Surface Platform

The architects of the building are Pilcher & Tachau and the consulting engineer is the Gunvald Aus Company, both of New York. The Connors Brothers Company is the general contractor and the Owego Bridge Company is the contractor for the structural steelwork, which was fabricated by the Cambria Steel Company and erected by the Pittsburgh Construction Company, of which C. L. McKenzie is president and J. W. Ghilon superintendent in charge.

Pier Construction at Baltimore

Design and Methods Employed in Municipal Work, Especially in Recreation and Commercial Pier Being Built

PRIOR to the Baltimore fire in 1904 that city owned practically none of its waterfront, and municipal port development was slow and expensive. After the fire, however, steps were taken toward a definite policy, under the direction of the Burnt District Commission, and $10,000,000 was raised, part of which was available for pier construction. Eight municipal piers have been built and another is under construction. A description of these works was presented at the second annual meeting of the National Association of Port Authorities by Oscar F. Lackey, who has been harbor engineer of Baltimore since 1907. These notes are taken from the February "Monthly Journal" of the Engineers' Club of Baltimore, in which his paper is reprinted.

The general plan of the first eight municipal piers was prepared by the Burnt District Commission and the former harbor engineer, and the lengths and widths of piers and distances between them were fixed by law. The piers are 200 ft. wide and vary in length from 551 to 1450 ft. The docks are 150 ft. wide. Until recently engineers have not given enough study to the width of slips, which, in Mr. Lackey's opinion, is of more vital consequence than the width of piers. If there is not enough available space amply to provide both he thinks width of pier should be sacrificed to the slip.

Baltimore's piers, with the exception of Nos. 7 and 8, are solid piers. The solid type was adopted for the reason that the old piers on the same sites were of bulkhead construction and the fill was practically made. In further defense of the solid construction, if the load is not imposed on the sheet piling the carrying capacity of the floor is good for 6000 or 8000 lb. per square foot. Even where there is no fill and the work does not extend back into made or solid ground bulkhead work may be cheaper than open construction.

First Construction

The first three piers are of pile and timber construction. An accurate force account was kept on the timber work, from which the cost of the timber piers was readily obtained. Investigations made about the time of their completion showed conclusively that the teredo had been active for some time about 4 miles down the river and that his activities were increasing in proportion to the rate at which the water was being purified by turning the sewage into the new sewerage system, all of which formerly ran into the harbor. With this and other information piers 4, 5 and 6 were designed.

[The bulkheads for these piers, which consist of elongated steel cylinders 25 ft. apart filled with concrete, and connected with concrete sheet piling, were described in detail in the Engineering Record of May 8, 1909, page 592, as were those of the earlier timber construction.]

RECREATION PIER

The substructure of the recreation and commercial pier is about completed. As the harbor widens out at this point, the pier was designed to allow a depth of water in docks of 35 ft. when needed. At this time the depth is 27 ft., being ample for those vessels which will use it at the present time. The docks are 190 ft. wide.

The pier is 150 ft. wide and 500 ft. long. For half its length it is a solid type, the outer half being open construction. The driveway for the depth of building is 35 ft., widening out to 58 ft. in width and paved with sheet asphalt. The outer half is paved for its full width. Later, after the fill has settled behind the sheet piling, the remainder will be paved.

The bulkhead is similar to that of piers 4, 5 and 6, except that the bottom of the marginal beam is at an elevation of 1 ft. 1 in. above mean high tide, and the beam and sheet piling are of larger section to take care of additional loads due to the greater depth of water. Two reinforced-concrete piles every 20 ft. center to center, were substituted for the cylinders. They are 15 x 15 in. in section. Another noticeable difference may be seen in the sheet piling. The piling in piers 4, 5 and 6 was 12 x 18 in., 27 ft. long, not interlacing or tongue-and-grooved, and carried no jet pipe. In the new pier the piles are 19 x 24 in., from 30 to 45 ft. long, with a 5 x 2½-in. tongue-and-groove and a 2-in. jet pipe, and weighing from 8 to 10 tons.

DRIVING PILES

Great difficulty was experienced in driving these piles. The character of bottom encountered was sand, mud and clay to 25 ft., then a stratum of white and red kaoline 4 or 5 ft. in thickness over a stratum of sand and large coarse gravel. Fully 80 per cent of all piles driven met with the above conditions and drove very hard; the remaining 20 per cent missed the stratum of kaoline, which tended to dip and leave the work near the outer end.

Three jets were used, one attached to the 2-in. pipe in the pile and two others used on the outside. A 7000-lb. hammer was placed on top and the pile churned by raising and lowering in the leads of the machine. It was necessary to drive them to a penetration sufficient to insure a toe hold.

This condition of kaoline over coarse gravel caused a blanketed state, making the action of the jets almost useless. The jet forcing its way through this hard, pasty substance would lose its effectiveness out through the coarse gravel and the condition looked for in all jetting work—that is, the dislodging of material and boiling up at the surface—never appeared. Other methods were tried, but with little or no success. The work required a great deal of patience, it taking in some cases four hours to churn a pile. Where the condition of the bottom changed, a pile was driven in from five to ten minutes.

CRANE FOR CASTING

The weight of these piles and the fact that there was not room at the site of pier to make and store them until seasoned required that they be built elsewhere and brought to the work as needed. A site was secured and a Gantry crane constructed. The mixer was so arranged as to dump into a bottom-dump bucket, which in turn rolled on an I-beam and could be drawn back and forth the length of the pile form. The crane would then advance to the next form and so continue until all piles for which forms had been constructed were cast. In about two days the forms were removed from the piles first cast and carried ahead by the crane. After piles were a week old they were allowed to be carried on quarter points by the crane to a storage pile, where they remained four weeks until seasoned. They were then picked up on quarter points by a floating derrick, put on deck and taken to the work. Sixteen hundred piles were used.

Profit or Loss with the Steam Shovel

An Analysis of the Various Elements which Produce Efficiency in Excavation Work and a Study of Their Proper Co-ordination

By P. S. FITZGERALD
Consulting Engineer, Moulton, Alabama

THE biggest thing in construction machinery is the steam shovel. Its capacity for results is so large that even most men engaged in operating steam-shovel plants do not comprehend its profit-yielding possibilities. Ranging from the little number 0 revolving shovel, for cellar excavating, to the mammoth 250-ton stripping shovels of the Kansas coalfield, its range of usefulness almost passes belief.

The monster 110-ton shovels of the Panama Canal and the 95-ton shovels for heavy railroad construction are marvels of power, mobility and effectiveness, while the 60-ton and 70-ton standard shovels for general construction are, beyond question, the most useful machines with which modern general construction is equipped. The vital and ever-new problem of getting maximum results at minimum cost is employing the scheming minds of every owner, superintendent and foreman engaged in steam-shovel work.

MAINTAINING MAXIMUM OUTPUT

As a general statement it may be said that it is not what a shovel will dig but what can be taken away from it that limits its output. It is common knowledge that a 70-ton shovel with 2½-yd. dipper will dig, if operated continuously, at the rate of 3000 cu. yd. in ten hours. How often this rate is attained for even one day, to say nothing of twenty-six consecutive working days, is such an idle question, apparently, as to bring the smile of indulgence to the face of the ordinary steam-shovel man.

If this average be possible—and it is possible in the same sense that it is possible for the expert shot to make 100 per cent in target practice—how vital and valuable, then, is the study and application of the means of its accomplishment! Some of us are prone to idealize, but to the average man perfection or near perfection is so remote as to lose its desirability.

If a shovel capable normally of delivering 3000 yd. daily at 33 1/3 cents contract price per yard, or $1000 daily return, only returns $333 daily, the owner may well "sit up and take notice" when he is assured of the certainty of correcting it. The most general use for steam shovels is on heavy railroad construction, where the quantities of material to be moved are so large as to justify heavy expenditures for the attainment of low-unit costs, and of such it is the purpose of this article to speak.

Contract prices for excavation are usually based on the classification of the material to be excavated, so that in a general way it may be assumed that the same degree of operating efficiency that will return $1000 daily in earth excavation will return about the same, plus additional expense for drilling, explosives, etc., in loose rock and solid rock. Hence the degree of operating efficiency shows practically the same proportional results in all classes of materials.

THREE VITAL ELEMENTS

There are three vital elements in steam-shovel operation: (1) The skill of the operating crew; (2) the upkeep and maintenance of the machinery, and (3) the provision for transporting the output. Under these three heads are numerous subheads, like so many links in a chain, the weakness or inefficiency or insufficiency of any one of which reduces the efficiency of the whole to its level.

The average labor, fuel, and oil expense of operating a standard shovel, not counting haulage, etc., or upkeep, may be assumed to be $40 daily, working under ordinary conditions and supervision. If the shovel digs 1000 yd., the cost is 4 cents per yard. If it digs 3000 yd., the cost is 1 1/3 cents per yard. But suppose that by doubling every item of expense either by increased wages for better men or larger crews, etc., the maximum of 3000 yd. could be maintained. The cost per yard, then, would be only 2 2/3 cents, or still a saving of 33 1/3 per cent over the cost of the 1000-yd. output. How many shovel owners realize and put this into practice?

Supposing, again, that the upkeep, repairs, new parts, etc., including half of the master mechanic's and blacksmith's expense, amounted in round numbers to $20 daily and that it was necessary to treble this to maintain the 3000-yd. schedule; the unit cost would still be no larger.

This brings us to the transportation problem—the "pons asinorum" of the average operator. Assume only usual or typical conditions—narrow-gage equipment, 4-yd. side-dump cars, and 10-ton dinkeys. How many operators use sufficient trains to keep one constantly ready at the shovel? How many lay their tracks to gradients that will permit safe and continuous operation? How many provide run-around tracks in the cut so as to have one train ready at the shovel on the second the loaded train departs? How many keep surplus—sometimes idle (though usually unnecessarily so)—labor ready to throw track, extend track, back the shovel, and do the many things that cause commonplace delays at the shovel?

Take a typical case. Assume a long haul—with three trains, dinkeys and crews, fuel, water supply, track gang, trestle gang, dump gang, etc. The variable labor-expense items due to more or fewer trains are train crews, fuel, water, track gang and dump gang. It is seldom necessary to add more than one train to "take up the slack" in the ordinary haulage system. Hence, with a daily cost of $40, the unit cost of 1000 yd. will be 4 cents, while with an increase to $60 for all items the 3000-yd. output will cost 2 cents per yard—or a saving of 50 per cent.

Thus by increasing the efficiency expense all around $100 daily—or from $100 to $200—the actual unit cost is decreased from 10 to 6 2/3 cents, or an additional profit of 3 1/3 cents per yard, which for 200 work days on the 3000-yd. schedule will amount to $20,000—sufficient to purchase outright an ordinary standard steam-shovel plant and have enough left to carry one month's payroll.

This, however, is the lesser of the two distinct profits to be gained by efficiency. If the contract price is 33 1/3 cents and the entire cost price, including interest, insurance, depreciation, temporary trestles, small-tool repairs, damage suits, overhead expense and the host of miscellaneous items incident to steam-shovel work, is, in the 1000-yd. case, 23 1/3 cents and in the 3000-yd. case 20 cents, the profit on 26,000 yd. per month is $2600 and on the 78,000 yd. per month $10,400, or four times as much. Not alone is the money a profit, but the reputation for prompt, efficient, successful work thus gained is a business asset that can hardly be reckoned in dollars. While the figures given are only illustrative, they surely serve to put in the spotlight that modern word for magic—efficiency.

Increasing Returns

The unthinking or overworked man is too prone to believe that in reducing expense lie profits. Never was theory so fallacious where results are measured in such large figures as in steam-shovel work. Additional expense for efficiency seldom outruns the gain, and never where brains, prudence and clear thinking are exercised. Of course, it is not intended to assert that by adding one train to three the carrying capacity will be trebled—but the idea is to provide ample transportation facilities so as not to delay the shovel at the maximum output.

It is the co-ordination of all the elements of the work that produces efficiency, and the principle here advocated is that it is the acme of intelligent economy to spare no expense, however seemingly extravagant, to bring about perfect co-ordination. For instance, many owners protest at more than four pit men, when as a matter of fact six would mean often 10 per cent gain in output; 100 yd. gain at 33 1/3 cents would seem a pretty handsome profit for an extra outlay of $4. For a shovel runner $200 per month seems high, but extra skill often adds 25 per cent to the shovel's output, or 6000 yd. monthly at 33 1/3 cents.

Many shovel owners scoff at such ideas and say there is nothing in them, but they seldom occupy high seats among the successful. Merely to spend money or pay excessive wages or keep idle or useless men is not the basis of this efficiency system, but not to withhold these things, when they are necessary and desirable, is the keynote. Co-ordination, ample facilities, brains, and everlastingly hitting the ball at maximum speed are the prime requisites, and combined they spell efficiency and profits.

Report of Philadelphia Transit Commission

Investigation and Recommendations for $57,000,000 Subway and Elevated Lines by Commissioner A. Merritt Taylor and Ford, Bacon & Davis, Consulting Engineers

THE report of the Philadelphia Transit Commission, dated July, 1913, and signed by A. Merritt Taylor, transit commissioner, and by Ford, Bacon & Davis, consulting engineers, consists of two 8 x 11½-in. volumes, one containing 267 pages of text and tables and the other 69 large folded maps, plans and diagrams. The report contains a thorough investigation of conditions, requirements and proposed construction, including a complete analysis of existing and future traffic, description of types of construction recommended and detailed estimates of cost, maintenance and earnings, which, together with the consideration of future rapid-transit operations, their effect and value, statistics of population and comparison with other cities, make the report thorough and complete.

The report commences with recommendations for the immediate construction of the most urgent work—a two-track subway delivery loop commencing at Broad and Arch Streets, a two-track subway line beginning at Broad and Walnut Streets and extending south, an elevated railway to Frankford and another to Darby, both beginning at Thirtieth and Market Streets. These lines, together with their equipment, involve a total cost of $57,578,000, of which $34,682,000 is to be expended by the city and the remainder by the lessees. It is estimated that additional construction and equipment for the extension of the system up to 1930 will, when added to this sum, bring it up to a total of $73,393,000, which is inclusive of interest during construction and exclusive of credit for pipe galleries and filling.

It is further recommended that the lines above mentioned be equipped and operated by the Philadelphia Rapid Transit Company, which shall also construct the elevated railway lines, and that the construction of the Broad Street subway be financed by the sale of city bonds. In case favorable negotiations with the Philadelphia Rapid Transit Company are not effected, the establishment by the city of an independent rapid-transit system with new surface line feeders will be necessary, and these have already been investigated.

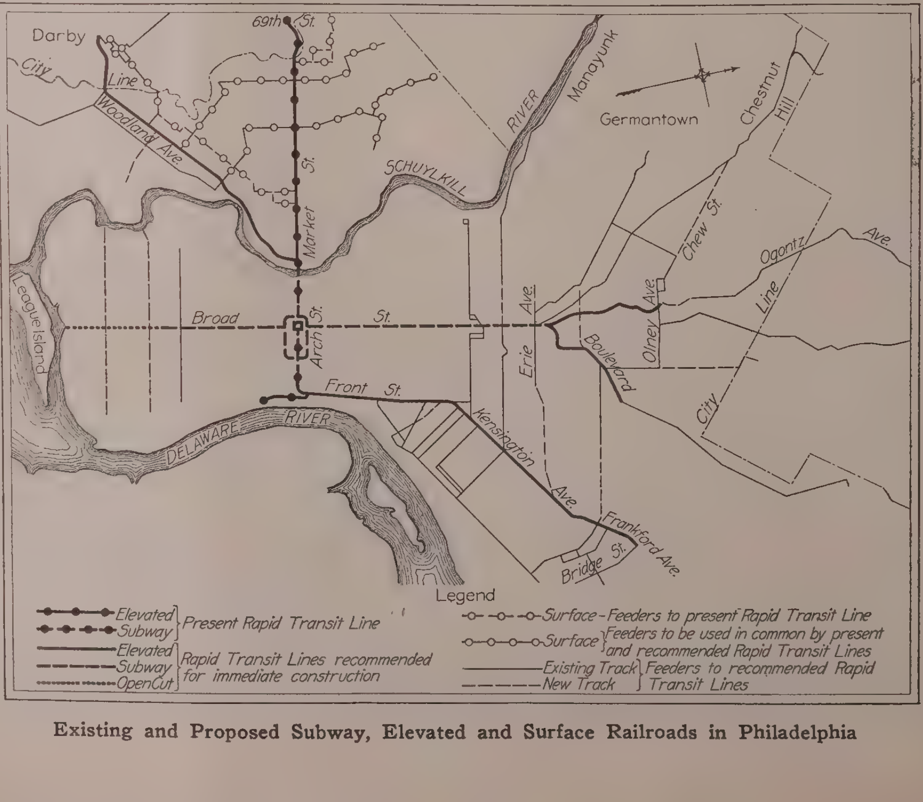
It is further recommended that where feasible all streets in outlying districts needed for future rapid-transit lines be widened as boulevards, to provide the best location therefor, and that all real estate which will be needed by the city in the near future for the development of rapid transit facilities, and which is likely to be improved by the construction of extensive structures thereon, be secured without delay.

Summary of Investigation

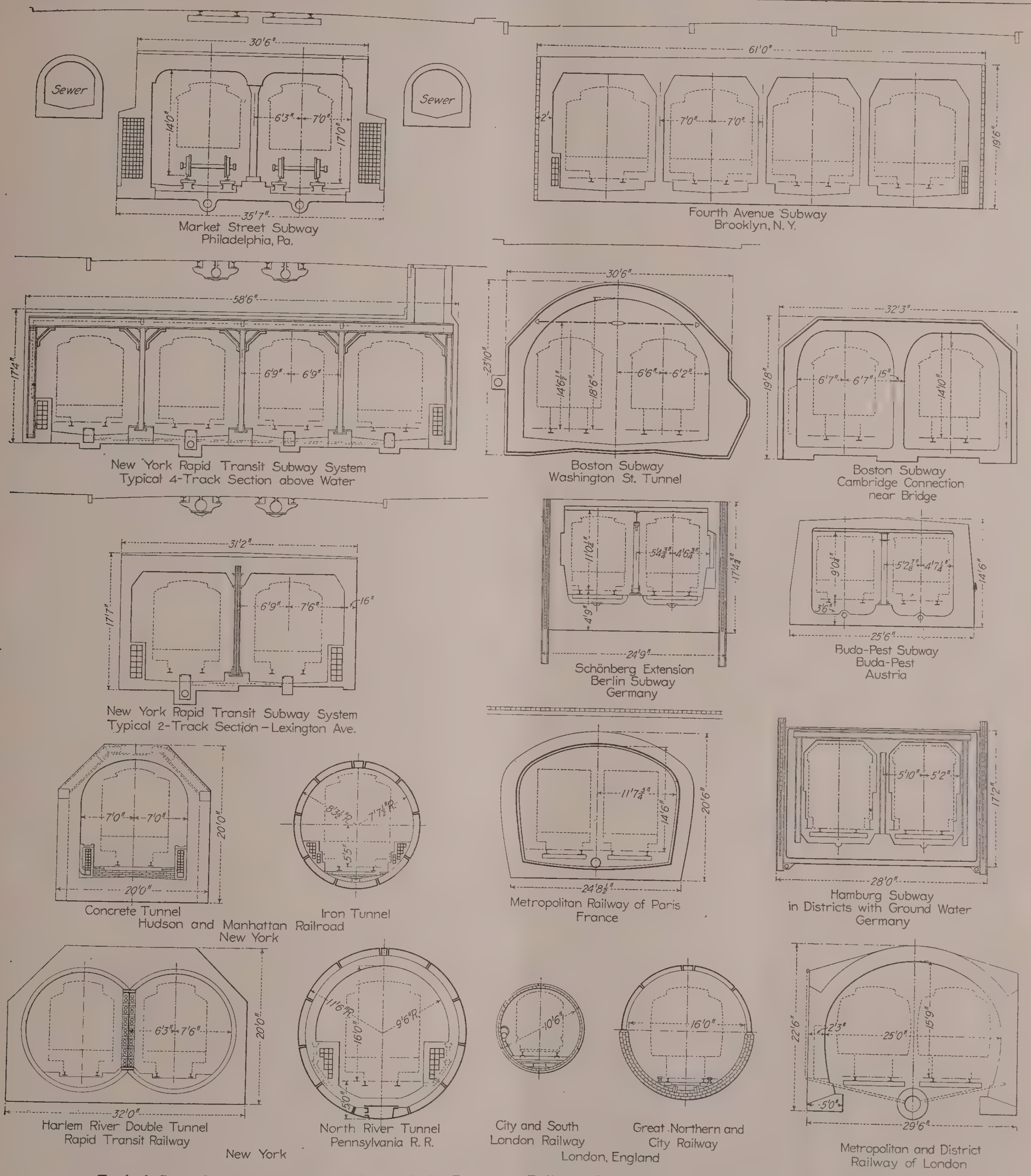
The report contains a complete, practical and technical investigation of four new rapid-transit lines to be located, an estimate of their cost and an analysis to determine whether or not they will be profitable in the broadest sense. On a basis of 2400 cars per hour the total capacity of the present and new lines is 206,000 passengers per hour, a rate more than double that of the present Market Street subway.

A number of feasible construction features and route locations have been considered and a general design has been adopted which limits the minimum radius of track at 165 ft., maximum ascending grade to 5 per cent, minimum headroom to 12 ft., and track centers to 12 ft. The plan eliminates grade crossings in subway, requires subway track laid on fixed ties without ballast, shows ballast floor construction for elevated railway with provision for third-tracking portions of elevated lines and open cut construction for part of the depressed tracks, and specifies cars with three doors on each side and none at the ends.

The total length of construction involved amounts to 8.6 miles of subway and 16.9 miles of elevated construction, making a



Existing and Proposed Subway, Elevated and Surface Railroads in Philadelphia



Typical Cross-Sections to Uniform Scale of the Passenger-Railroad Subways of the Principal Cities of the World

total of 59.3 miles of track for the first development of the recommended system, or 56.9 miles of track if it proves necessary to construct an independent system. Assuming that the definite designs for these lines are commenced on July 1, 1913, it is expected that the elevated lines might begin operation on Jan. 1, 1917, and the subway lines one year later, and that the general construction would be completed in 1919.

It is estimated that incidentals, contingencies, engineering, organization, administration, legal and financial expenses, interest during construction and cost of investigation will be covered by allowing overhead charges of 30 per cent on subway construction, of 25 per cent on elevated structure, and of 20 per cent on equipment for both subway and elevated construction. Space reserved in the subway for additional water mains will eventually be needed by the city and justifies a credit of $1,920,000 to the subway investment. Another credit of $236,000 may be allowed for excavated material to be used for filling streets. Detailed calculations of returns of total investment vary from $2,441,900 in 1921 to $4,399,100 in 1930, with corresponding rates of 4.1 per cent and 6 per cent. In estimating the economic value to the traveling public it is calculated that the time saving for passengers will amount to 12,928,300 hours in the year ending June 30, 1921. At 15 cents per hour this amounts to $1,939,000, which being capitalized at 5 per cent is $38,780,000.

Volume 2 of the report consists entirely of large folded maps and plans, most of them printed in colors and affording a graphic and exhaustive study of the transit situation in Philadelphia. The first section is devoted to the comparison of passenger-transportation facilities in Philadelphia, New York, Chicago and Boston, and contains 23 maps showing steam and electric passenger lines, time zones and steam and electric railway fare zones for Philadelphia, New York, Chicago and Boston, many of them superimposed. The development of time saving by rapid transit is shown by five maps of different sections and routes. Population, volume and distribution of traffic and estimated earnings of the railways are shown by thirteen maps and diagrams of different sections of the city. Recommended lines are shown on six maps; plans for both subway and elevated structures and stations include twenty drawings, besides which there are diagrams for time-distance train movements. One plate shows to uniform scale the different cross-sections of the rapid-transit subways and tunnels in ten great cities in America and Europe.

Volume of Chemical Change during Water Purification

NO information or conception as to the amounts of material carried by a stream during a long period of time is obtained by the ordinary form in which the results of water analyses are reported. At the last meeting of the Indiana Sanitary and Water Supply Association C. K. Calvert, chemist of the Indianapolis Water Company, presented data on the White River at Indianapolis that give one a new viewpoint. Based on four years' results, some of the amounts, expressed in tons, of material per square mile are: Sodium chloride, 8.2; magnesium sulphate, 61.5; magnesium carbonate, 43.2; calcium carbonate, 17.3; total solids, 350.3; suspended solids, 44.5. The ammonia content was 436 lb. and the nitrous-acid radical, 96 lb.; the oxygen required was 106,112 cu. ft., and oxygen dissolved, 201,579 cu. ft.

Total solids per year are 434,400 tons, equivalent to a layer 0.003 in. over the whole 1240 sq. miles of watershed.

Estimating the number of bacteria per pound at 320,000,000,000, about 2500 tons of living organisms pass Indianapolis each year.

Based on the 1913 analytical data, the filter plant at Indianapolis effected a removal in the water of 660 tons of insoluble matter, 45 tons of iron, 28 tons of aluminum, 25 tons of calcium and 34 tons of magnesium. As aluminum sulphate was used during a portion of the year, the sulphuric-acid radical showed a gain of 189 tons. Further losses in tons are: Total solids, 775; ammonia, 4.4; nitrous and nitric-acid radicals, 1.56 and 13.7, respectively; of the oxygen required and dissolved there was a loss of 1,249,171 and 1,028,531 cu. ft., respectively. Although these amounts are little short of terrifying, assurance is regained when calculations indicate that the total consumption during a 70-year life would contain only 54 lb. of solid matter.

CHEAP transportation for the market products raised on irrigation projects is provided by the Australian Government before farmers are asked to settle on such districts. This cheap transportation is established by canalization of the rivers and the building of railroads. Such roads, necessarily operated at a loss during their first few years, are said to be now earning 6 per cent on money borrowed at 4 per cent.

Garbage Reduction Recommended for Detroit

Résumé of Reports by Two Engineers on the Garbage-Disposal and Collection Problem for a City of 500,000 People

FOLLOWING extensive investigations, reduction of the garbage of Detroit, Mich., in a municipal plant of 300 tons capacity in a sixteen-hour day, to cost $473,000, has been recommended by George H. Fenkell, commissioner of public works. As a check on his own conclusions, which were made after careful local investigation and visits to most of the large cities in the central West and observation of their collection methods, he had the subject investigated by T. H. Hinchman, Jr., an engineer in no way connected officially with the city. From these two reports the following notes are taken:

In Detroit either reduction or incineration may be operated successfully from a sanitary standpoint, but as garbage is subject to rapid decay, it becomes apparent that the success of any plant must depend largely on the efficiency of its management. Should the incinerator be adopted it is proposed that all garbage, ashes, rubbish, papers, sticks, leaves and other waste shall be mixed by the householder, and that all will be removed by one collection. Should the reduction method be employed the garbage would be stored and collected separately in the manner now practised in Detroit. Any careful consideration reveals the fact that the best method to adopt will depend to a considerable extent on local conditions. Mr. Fenkell is of the opinion that in order that garbage be handled in the most sanitary method it should first be deposited in a tight metal or concrete can or box, having a close-fitting cover; that under no circumstances should it be mixed with ashes or rubbish; that it should be collected frequently and transported in tight metal wagon boxes.

FREQUENT COLLECTION

Too much emphasis cannot be put on the frequent collection of garbage. During the summer months ashes are made in but small quantities in the residence district, while during the winter months they greatly exceed all other waste. As deposited for collection they are probably as free from disease-producing germs as ordinary top soil, and it therefore appears there can be no good reason why they should not be placed in dumps. Ashes have some value as fuel because of the unburned coal and coke they contain, and it is claimed that they may be used in the manufacture of brick. When the investment and proper charges are taken into account the use of ashes in an incinerator to make use of the heat in the unburned coal is uneconomical. Mr. Fenkell believes that the cost of operating and maintaining steam boilers will exceed the value of the steam produced and that the market for the ash will be so limited that a considerable portion of that produced will have to be taken to dumps at no little expense. That is, the income from the sale of the ash clinker will not equal the cost of treatment and final disposition.

A reduction plant separates garbage into four parts—rubbish, water, grease and tankage. An effort is made to reduce the amount of rubbish to a minimum, and its value is small; the water is evaporated to obtain the fertilizing elements in solution; the grease is the most valuable of any of the products and is used in the manufacture of soap in the United States, and considerable quantities are exported; the tankage is dried and sold to fertilizer manufacturers.

An examination of the reduction plant at French Landing makes it evident that the plant and its equipment are unsatisfactory, although the location is well adapted to the purpose. In the construction of a reduction plant it is desirable that good railroad facilities be provided so that as far as possible all garbage may be delivered in covered steel cars, and it is believed that a plant so located, with sufficient capacity to care for all the garbage from the city, is preferable, from a sanitary standpoint, to several incinerators or reduction plants scattered about the city. Mr. Hinchman recommends and Mr. Fenkell agrees that the proposed contract for an incinerator be not entered into because the garbage of Detroit can be disposed of at a reduction plant in a safe and sanitary manner, without nuisance, at less expenditure for the cost of installation and for an annual profit of at least $25,000, in contrast to an annual expense of $135,000, as contemplated by the incinerator method.

PRESENT CONDITIONS

Under the present system the garbage is reduced; pure ashes are used for filling alleys and streets, but where mixed with rubbish are taken to the dumps; rubbish is in general carried to the dumps, but in some cases light combustible matter is burned in wire baskets in the alleys; infected rubbish, such as infected bedding, is burned; manure is in general shipped to nearby farms for fertilization.

Householders are required to have separate receptacles for ashes and rubbish, and for garbage. The success of the system from a sanitary standpoint depends on the care with which the garbage is separated from other materials, the promptness with which it is collected and the cleanliness of the wagons.

The difficulties in the way are the large area to be covered, the unpaved alleys, the large quantity of material to be handled, the variations in quantity at different seasons, the cold winter weather and the breaking of the winter, when the alleys are passable only with great difficulty. While there are some complaints, it may be said that there is an earnest endeavor on the part of the large force of men in the collection departments to carry out the work in a thorough and workmanlike manner. It can also be said that the condition of the alleys and dumps is better to-day than it ever has been. This is due to better organization, better system and more co-operation on the part of the householder. An examination of the dumps shows very little garbage, though there is some, due to lack of proper separation. It is not sufficient to be objectionable, and property owners in general are glad to have their lots filled. There are some fires in the dumps, but they are not sufficient to cause complaints. The alleys in the downtown districts are at this time in exceptionally good condition. There has been little complaint on the condition of the garbage wagons since canvas covers were adopted and the wagons disinfected.

This matter was gone into at some length by Mr. Hinchman because it was expected that the statement would be made that conditions were so bad under the present system as to make it necessary to change the system of collections to the mixed system of collection.

GARBAGE PRODUCED

The garbage weights are kept by days and these weights are used. There is no separated record for ashes and rubbish, but a combined record of loads by weeks is kept from which the weights have been computed. The loads average 4½ yd. each and the weight per yard is estimated at from 0.373 ton per yard to 0.408, depending on the season of the year. This variation is due to changes in the amounts of rubbish, which decrease in the winter time to about 5 per cent of the ashes by weight and increase in the summertime to as much as 15 per cent by weight. The annual production is 57,179 tons of garbage and 200,063 tons of ashes and rubbish, of which about 20,000 tons are rubbish. The maximum daily collection of garbage is approximately 250 tons, this figure being the maximum day in August and September, during which months the garbage collections are greatest, due to green vegetables.

The maximum daily collection of garbage, ashes and refuse occurs during May and amounts to 175 tons of garbage (monthly average) and 1496 tons of ashes and rubbish (weekly average), a total of 1671 tons of refuse per day. This is due to the removal of the accumulation of the winter's ashes and rubbish previously unavailable on account of frost, snow, storage in cellars and impassable alleys. The garbage receipts are increasing at the rate of approximately 5500 tons per annum, so that in the calendar year of 1915 there should be at least 68,000 tons. At that time the maximum daily receipts should be 300 tons.

The ashes and rubbish will amount to at least 220,000 tons in 1915, but the maximum day should not greatly exceed that of 1913.

PLANS PROPOSED

Of several plans which may be adopted, the first is to continue the present contract. The merits and demerits of this plan will not be discussed at length because it is generally admitted that whatever the nature of the disposal plant, it should be owned and operated by the city in order to secure the best results in the matter of continuous and certain service, sanitation, safety and prevention of nuisance. The city is also entitled to any profit which may accrue from the disposal plant.

The second plan is to build incinerator plants of sufficient number and capacity to take care of all the refuse of the city. This plan admits of a mixed system of collection. It would leave 75,000 tons of clinker to be disposed of after incineration of the refuse. The plant capacity required will be at least 1200 tons per day.

The third plan is to build incinerating plants of sufficient capacity to take care of the garbage, incinerating only such part of the ashes and rubbish as is necessary to secure combustion. Ashes and refuse required will be from 30,000 to 60,000 tons per year. This plan calls for a separate system of collection. The proposal for an incinerating plant now under consideration presumably falls under this plan.

It is proposed to build northeast of the city an incinerating plant of the most modern description, having a capacity of 100 tons of refuse per day of twenty-four hours. The performance guarantees are based on the consumption of 45 tons of garbage, 40 tons of ashes and 15 tons of refuse per twenty-four hours. The time of completion required is 250 working days and the cost is to be $83,900, exclusive of the amounts required for side track, sewers, water supply and preparation of site, which will eventually require the expenditure of about $20,000.

If five plants are ultimately required, and the expense is at the same figures, the final cost of the garbage-disposal plants will be between $600,000 and $700,000. The reason for the excessive cost per ton of capacity of this proposed plant is its small size and the fact that land, sidings, sewers and water connections will have to be provided at each of the plants, whereas, if the plant were all concentrated at one site these initial expenses would have to be borne only once.

FACTORS DETERMINING AWARD OF CONTRACT

The specifications provide that the quantity of clinker in the plant and the quantity of steam produced shall be determining factors in awarding the contract for the plant. The clinker may be of some value in some places, but its value in Detroit is problematical. If there were not available the best gravel and limestone for concrete work and an unlimited supply of cinder for rough filling, the case might be different. So far as can be seen at this time the clinker will not be a source of profit but a matter of expense. At Milwaukee it is used for filling in the lakefront.

Steam to be generated by the waste heat is given an arbitrary value of 30 cents per 1000 lb., but as far as the contract is concerned there is no means of disposing of the steam generated or realizing this money from its sale.

The fourth plan is to build a reduction plant, to be owned and operated by the city, to take care of the garbage; to supplement this plant with some small destructors for inflammable rubbish, and to use the ashes as at present for roads, alleys and low properties.

In considering garbage-reduction plants it must be admitted that their history is against them and that almost all writers agree in saying that they are dangerous on account of liability to fire and explosion, as well as a nuisance on account of odors. As a matter of fact, none of these charges is necessarily true. It is not only possible but easy to build a reduction plant which will be neither dangerous nor a nuisance. This is not a mere statement of what can be done, because the fact is demonstrated at Columbus, where there is a municipally operated reduction plant which is as safe as the most timid can desire, and is as sanitary as a well-kept kitchen. It is light, well ventilated, free from disagreeable odors and clean. The effluent from the plant is not a nuisance and the worst waste is the ordinary cinders and slag from the boilers.

The cheapest installation of the incinerating plant on the basis of distributed plants is $635,000, as compared to $473,000 for a reduction plant. In the matter of cost of operation there is a choice between making a profit of $25,000 with a reduction plant or incurring a loss of $135,000.

Sewage-Plant Management

Plea for Operators Who Understand Principles of Treatment and Regulation

THAT persons in charge of sewage-disposal plants should understand the principles of operating the plant and that they should be thoroughly familiar with the details of installation are two essentials for the success of the small plant, according to Charles Brossmann in a report presented Feb. 27 at a meeting of the Indiana Sanitary and Water Supply Association. Further requisites noted are: Operators should understand the dosing apparatus and know how to make adjustments when out of order; how to tell when the sedimentation or reduction tank is operating properly, whether too much suspended matter is going to the filters or whether too much sludge has accumulated in the tank, and also when contact beds are overworked or when sand filters are clogged and need to be raked. "It does not take a technically trained man to know these things," said Mr. Brossmann, "but one who will look after the plant at regular intervals and keep track of what it is doing. At municipal or public plants the city or county engineer would direct such work, and at public institutions the chief engineer is usually fully capable of getting results if he will devote the necessary time to the problem.

SUGGESTIONS FOR PLANT MAINTENANCE

For plants that cannot receive expert supervision, the following suggestions were given: As the purpose of septic and Imhoff tanks is mainly to separate and retain suspended matter, the tanks should be kept in such condition that this may be accomplished. Large accumulation of septic sludge should be avoided when it causes violent ebullition and a consequent carrying of the sludge to the filters.

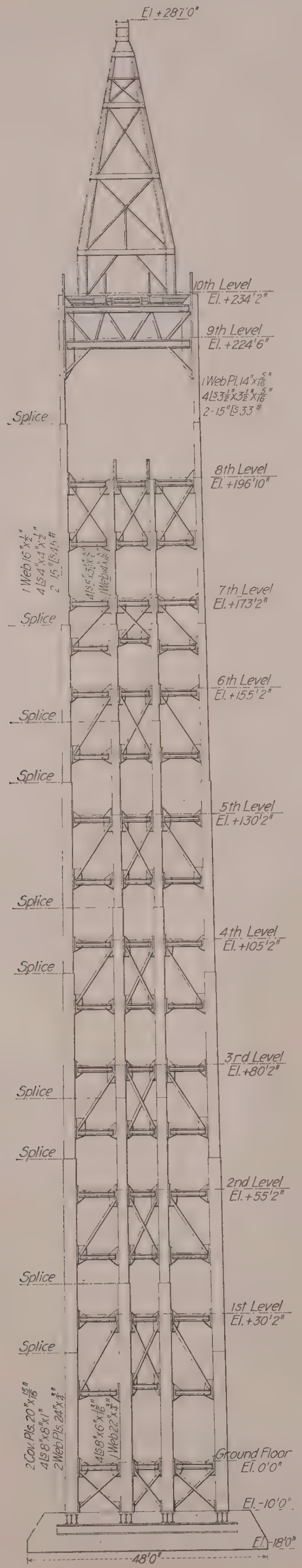
Sludge in Imhoff tanks should not be allowed to get above the depositing slats at the bottom of the settling chamber. Blow off the sludge at regular intervals or at times of high water, unless provision for drying is made. Large and unusual storm flows should be diverted by the tank.

CLOGGING FILTERS

As the main trouble with contact filters is the tendency to clog, they should not be overworked and should be given stated periods of rest. "While it is impossible to prevent some suspended matter from being carried over from the tanks, they should be cared for so as to cause the least trouble by catching as much of it as possible before it works into the bed. Proper and complete underdrainage assists greatly in getting rid of accumulations, but," said Mr. Brossmann, "few beds are very thoroughly underdrained."

Although sand filters are not so liable to give trouble as the contact bed, the surface should be kept free of material that will clog. When ponding occurs, rake the bed to a depth of about ¾ in. The bed can be allowed to dry, when the top skin will peel. It can then be raked off. Fill low spots so that the sewage will cover the bed evenly, thus working all parts of the bed uniformly. Furrow the surface in freezing weather.

Operators not getting proper results from their plants, or noting unusual conditions, should notify the State Board of Health.



Tower Columns and Bracing

An Earthquake-Proof Tower

Semi-Flexible Construction Selected for Steel and Concrete Structures, 303 Feet High, at Berkeley, California

By ERLE L. COPE
Civil Engineer, San Francisco

THE Jane K. Sather campanile which is being erected at the University of California at Berkeley, Cal., is a steel and reinforced-concrete structure faced with California granite. It will have a height of 303 ft. from the ground to the top of the lantern. The foundation is 18 ft. below the ground, making the total height 321 ft. It is square in plan, 33 ft. 9 in. wide at the base, tapering to 30 ft. 6 in. at a height of 189 ft. 6 in. above the ground. Above this point the walls are vertical except in the pyramid at the top. There will be a clock on each side of the tower, 180 ft. above the ground, and a chime of bells at an elevation of 220 ft.

FLOORS AND WALLS

There are reinforced-concrete floors, called levels, approximately 25 ft. apart up to an elevation of 200 ft., and from there on at irregular intervals. They are designed for a live load of 60 lb. per square foot. Reinforced-concrete stairs extend from the ground level to the top and an elevator runs from the ground to the seventh level. The public will probably not be admitted above the eighth level or belvedere, at an elevation of 197 ft.

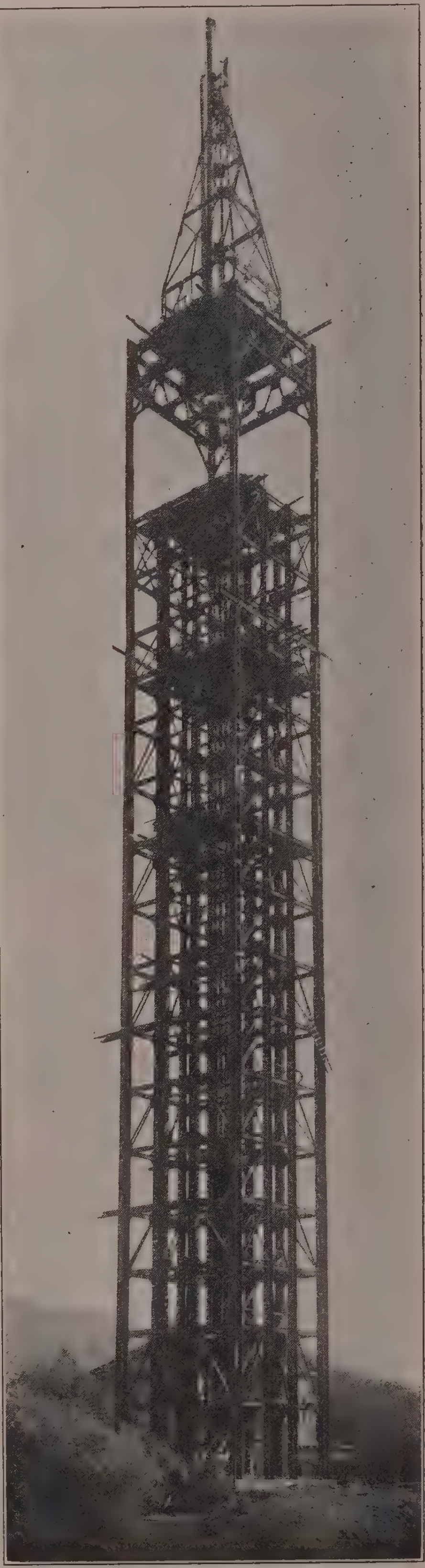
The stone facing of the walls is thoroughly anchored to a reinforced-concrete backing, which is 6 in. thick at the thinnest part. The walls are carried on the steel frame. In their construction only two or three courses of stone are placed at one time. The stones are securely tied together, and galvanized-iron anchors are provided, projecting inside and fastened to the wall reinforcement. Concrete is then poured to the top of the stone. Forms are required on the inside of the wall only, but great care must be exercised or the stones will be pushed out of place. As the stones are of different thicknesses the wall built in this manner is practically a monolith.

STEEL FRAMEWORK

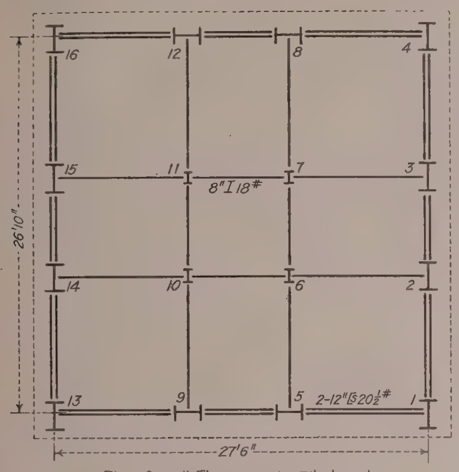
The steel frame is composed of sixteen columns, symmetrically placed about both axes of the tower and tied together with beams at each level and also at points midway between the levels up to the belvedere. The wall columns have the same batter as the walls from the foundation to elevation 167 ft. 7 in., above which they are vertical. On account of the architectural treatment, only the four corner columns are carried above the eighth level, and these terminate at the tenth level, where they carry four trusses, which in turn carry all of that part of the tower above. The framing above the tenth level consists of beams and and angle struts.

The form of bracing is shown in the elevation diagram. Windows occur in the middle bays on all four sides just above the levels, and this feature, coupled with the desire to allow sufficient flexibility in case of earthquakes, determined the omission of bracing in alternate stories. This arrangement throws large bending stresses from wind into the columns, but at the same time provides a frame flexible enough to deflect a considerable amount without shearing the rivets in the connections of the diagonals or causing the members themselves to fail. Some of the buildings with diagonal bracing that went during the San Francisco earthquake of 1906 were seriously damaged because they were so rigid that they could not deflect without rupturing the braces.

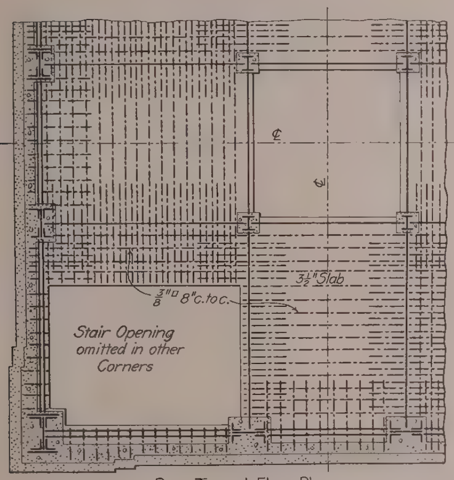
The following unit stresses were used in the design: Extreme fiber stress in beams from dead and live loads, 16,000 lb.; combined direct compression and flexure from wind (main columns), 14,000 lb.; combined direct compression from wind and



Completing Erection by Guy Derrick



Plan for all Floors up to 7th Level



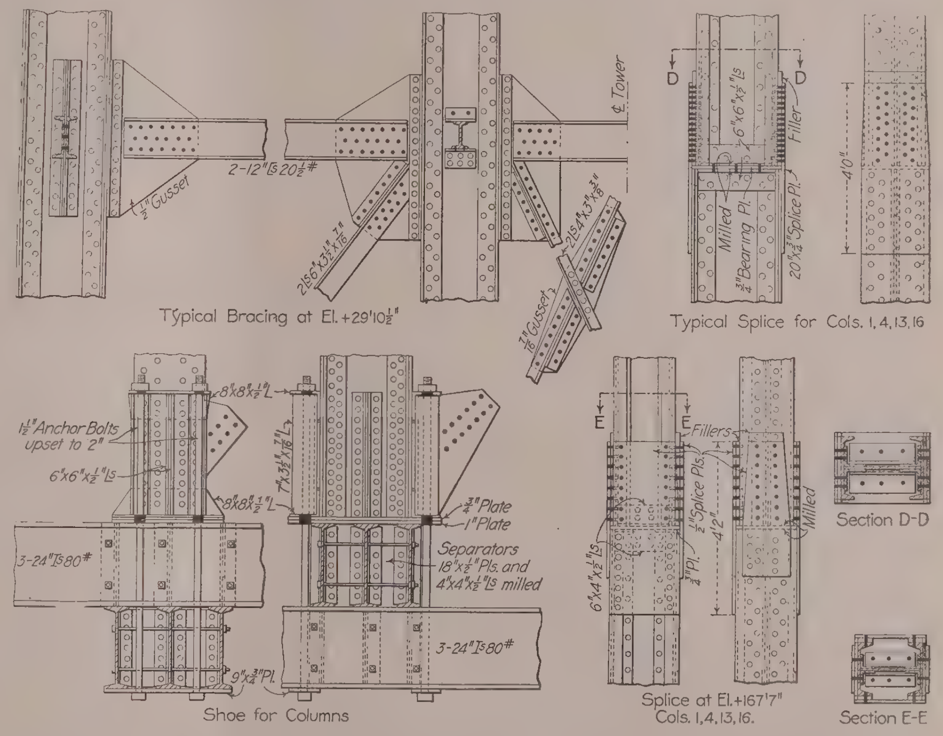
Part Typical Floor Plan

Floorbeams and Concrete

flexure from dead and live loads in wall beams, 18,000 lb.; direct compression in wind braces, 10,000 lb.; shop rivets, bearing, 15,000 lb.; shop rivets, shear, 9000 lb.; field rivets, three-quarter values of shop rivets; bearing of steel on concrete, 40,000 lb. per square foot; extreme pressure on foundation, including wind, 7000 lb. per square foot.

The columns are spliced midway between the beams at points of contraflexure. The splices are heavy enough, however, to take some bending if any should come on them.

A wind pressure of 20 lb. per square foot was used. With the stresses used this is equivalent to a pressure of 32½ lb. per square foot with the stresses recommended by the American Railway Engineering Association. The American Bridge Company, in its specifications for steel structures, adopted 1912, recommends a wind pressure of 20 lb. per square foot with allowable stresses in the columns increased 25 per cent over those allowed for dead and live loads alone. The unit stresses adopted in this design are more conservative than either of these.



Typical Bracing at El. +29'10½"

Typical Splice for Cols. 1, 4, 13, 16

Shoe for Columns

Splice at El. +167'7" Cols. 1, 4, 13, 16.

Section D-D

Section E-E

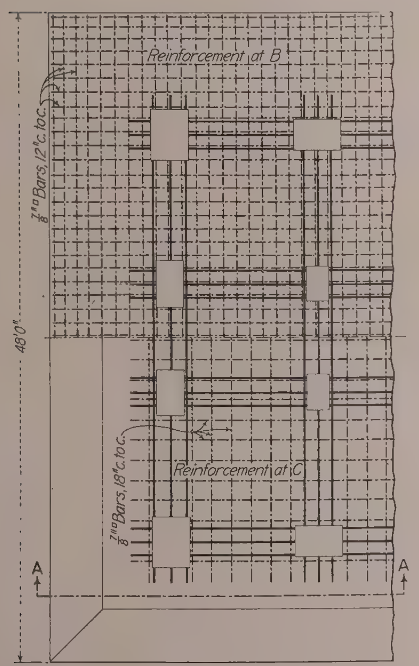
Details of Column Splices, Wind-Bracing Connections and Anchorages

FOUNDATIONS

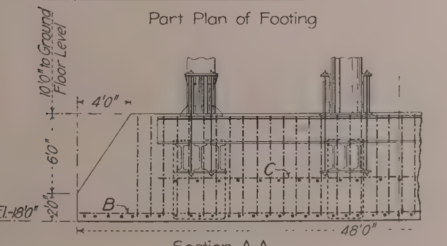
Cast-iron bases for the columns were avoided by using built-up shoes of structural steel shapes, which rest directly on the grillage beams. Each column is anchored to the under side of the grillage with four 1½-in. bolts upset to 2½ in. The foundation consists of a reinforced-concrete slab 48 ft. square and 45 in. thick, upon which rests a grillage of 24-in. 80-lb. I-beams. The grillage is covered with concrete, which is firmly bonded to the concrete slab below with stirrups, which are made of ½-in. square rods. This foundation rests on a stratum of boulders and hard gravelly clay. Borings show the bedrock to be 45 ft. below the bottom of the slab.

The campanile was designed by John Galen Howard, supervising architect of the University of California. The steel frame, floor and stair slabs and foundations were designed by the writer. Charles Derleth, Jr., of the University of California, acted as consulting engineer.

There are 501 tons of steel in the structure, which were fabricated by the McClintic-Marshall Construction Company, of Pittsburgh, through the California Construction Company, of San Francisco. The latter company had the contract for the frame erected. The Clinton Fireproofing Company had the contract for the concrete.



Part Plan of Footing



Section A-A

Continuous Foundation Slab

Driving Foundation Piles with a Follower

PILES in the foundation for the piers of the double-track railroad bridge across the Rancocas River, New Jersey, were satisfactorily driven under water by the use of an oak follower. The pier sites were inclosed with wooden sheet-pile cofferdams and were excavated to a depth of 17 ft. below low water. The foundation piles were cut down from 30 to 18 ft., in accordance with the results obtained by the penetration of test piles, and were driven 2½ ft. apart on centers by a machine supported on top of the cofferdam.

The piles were driven through fine hard sand to a penetration of about 16 ft. by means of an oak follower provided with a 12 x 1-in. welded iron collar which was secured by railroad spikes driven around the upper edge and which projected 8 in. below the bottom of the follower to form a socket engaging the top of the pile. About one pile per hour was driven. Considerable difficulty was experienced in maintaining the piles vertically during driving. Soundings taken after the driving was completed showed that the displacement had caused the bottom of the excavation to rise about 2 ft.

The piles were driven by the Stillman-Delehanty-Ferris Company, of Jersey City.

ELECTRIC-PROCESS pig iron is now being produced in Shasta County, California, at about $14 per ton. The same grade at Pittsburgh costs $17.25 per ton.

Introducing a Road System in Alaska

Current Report of Military Commissioners Shows 862 Miles of Wagon Road Built Since 1905 at Average Cost of $2489 per Mile

LOCATING and constructing adequate wagon roads and pack trails on frozen ground in a country of 600,000 sq. miles, boasting practically no thoroughfares but the rough footpaths, was the task assigned the Board of Road Commissioners of Alaska, which was created from the army ranks under a Congressional act dated Jan. 27, 1905. The report of this committee, which at present includes W. P. Richardson, lieutenant-colonel of infantry, Glen E. Edgerton, first lieutenant, Corps of Engineers, U. S. A., and L. A. Kunzig, first lieutenant, Thirtieth Infantry, for the fiscal year ended June 30, 1913, states that since the establishment of the first office in Skagway in the summer of 1905 there have been constructed and maintained to connect permanent settlements 862 miles of wagon road, 617 miles of winter sled road, and 2167 miles of trail—of which the miles to be credited to the last year are 33, 18 and 614 respectively. The average costs per mile, including maintenance and overhead charges, are: Wagon road, $2,489.68; winter sled road, $278.80, and trail, $90.44.

Compass Location Under Difficulties

When the work was inaugurated travel was mostly confined to the open waterways in summer and over their frozen courses in winter. There is little of level area in the territory, states the report, except the moss-covered tundra of the far north and northwest. The coastal region as far west as Cook Inlet is extremely rugged and broken, wet, and heavily timbered, especially on the seaward slopes, the timber becoming lighter toward the west. The valleys of the interior or central portion are fairly well timbered near the streams, and covered also with a dense growth of underbrush, overlaid with a blanket of moss, beneath which the ground is usually frozen to great depth. These valleys are transformed in summer through the melting snow and surface thawing into morass and swamp, through which travel on foot or on horseback is a slow and laborious process. As one leaves the stream valleys the timber becomes lighter, and on the hill slopes fairly good ground may be found, and in a few places considerable areas of dry gravel bench exist, but nowhere is it possible to use wheels for any considerable distance without some sort of prepared roadway.

To solve the problems of location under these trying conditions it was decided to use compass and chain only, giving the grades by vertical angulation, as it was felt that in the hands of experienced men these methods, while rapid and flexible, would afford results of sufficient accuracy. A few surveys, however, have been made by the method of deflection angles and differential leveling.

Building on Frozen Ground

The wagon roads constructed are located with suitable grades, crowned, ditched and drained, and corduroyed or planked where necessary. The winter sled road is not crowned, ditched, drained, or extensively corduroyed, and is of sufficient width through the timber and on sidehill cuts for double teams, of suitable grade for loads, and with the principal stumps and surface inequalities removed. The winter travel begins in early October and lasts to about the end of April. The trail differs from the winter sled road only in being narrower and with less attention being given to grade and surface inequalities. The total width cleared, as a rule, has been 24 ft., and the actual width of roadway has been, in most cases, 12 ft.

The great obstacle to road building in Alaska, outside of the heavy cost on account of the high prices for labor and teams, is the fact that a large portion of the soil, except on the Pacific Coast, is permanently frozen to an unknown depth, the surface being protected from thawing during the summer by a thick blanket of moss or turf. This frozen ground often contains masses of solid ice locally termed glaciers. It occurs principally in bottom and lower slopes of the valleys, although the higher slopes are sometimes frozen. Even in the valleys, however, small swales and streaks of dry and consequently unfrozen soil are often found. The frozen ground varies in composition. In the Tanana Valley it is the detritus of the mica schist country rock; in the Rampart section, the clayey detritus of the slate country rock; on the Seward peninsula, a peaty muck.

Slides in Cuts

If the frozen soil is gravel it does not, as a rule, contain solid ice, and the ground may be stripped and graded as usual. The face of sidehill cutting runs and slides very badly when first exposed to the sun, and the roadbed is ordinarily wet and soft. It is not expected, however, that these effects will continue after the gravel is once thawed and drained. Where timber was at hand and the immediate need of the traffic great, as in the Fairbanks district, a light-pole corduroy was usually laid to permit the immediate use of the road.

In localities, also, where the frozen ground is of a clayey nature, so that it has some consistency when thawed, is not badly glaciered, and where immediate demand of wagon traffic is not great the road may be stripped and graded. This was the case at Rampart.

Where, however, the frozen ground is the mica schist muck of the Tanana Valley or the peaty muck found in other places, stripping the moss or turf is entirely out of the question. The resulting road would be an impassable quagmire, gullied and cut deep below the surrounding ground. The protecting blanket of vegetable matter must be left in place, to the end that the ground underneath be kept frozen and solid. This layer of vegetable matter is, however, unable to sustain traffic, and is covered by a pole-corduroy, as of spruce timber.

However, several seasons of sun upon a cleared roadway, coupled with systematic drainage, have enabled a very fair road to be made without corduroy or gravel surfacing in certain sections where this seemed impossible on first examination. Such roads will, however, become muddy and rutted in rainy weather and under much traffic.

Ditching

The ditches, in frozen soils of the nature considered, are a matter of considerable difficulty. They are necessary, as such ground is very wet on the surface, and soft and unstable as the moss or turf is when dry it is far worse when wet. Without ditches the roadbed would probably sink below the level of the surrounding country, and would become a ditch in itself. Moreover, in the case of corduroy roads, the cheapest source of the earth covering is the ditch. If the ditches have even a slight grade, however, they are liable to wash and cut very badly, as is easily understood when it is remembered that portions of the ground are almost clear ice. In some instances the ditches have in a very short time cut clear under the corduroy, necessitating that it be removed, the space filled with thawed ground and sod and revetted with moss or sod. Even when cutting is not so bad as to undermine the roadway the deeply cut ditches close to a road are dangerous to wagons. To mitigate the undesirable features of such ditches a berm is left between the corduroy and the ditch, and where the ground has any side slope the ditch on the lower side is omitted. Considerations of economy of construction have in some cases led to placing the ditch next to the corduroy, as the earth is so wet that it would otherwise have required an extra line of shovelers between the ditch and the corduroy. It is believed, however, that the advantages of a berm between the road and the ditch outweigh its extra cost. In addition to leaving a berm, culverts and outlet ditches are constructed at intervals of 300 ft. or less, to carry off the water, reducing the scouring to a minimum.

Methods of Financing

All revenues derived from liquor licenses and occupation and trade licenses in the territory are deposited in the U. S. Treasury as the "Alaska fund." At present 65 per cent of this amount, totaling $1,160,829.62 to date, is devoted to road and bridge construction and improvement. At intervals Congress has made special appropriations amounting to $1,375,000, making the sum available to date $2,535,829.62. Donations totaling $20,000 have also been made by the towns of Fairbanks, Nome and Cordova, and by some large mining operators; road taxes have increased the available funds somewhat.

The Alaskan legislature has recently requested that the Congressional appropriation be increased, calling attention to the fact that about $55,000 of the $155,000 set aside for the current year will be required to build a dam to protect Government property near Valdez. The engineer officer of the board has estimated that $7,250,000 will be required to complete and maintain a system which would meet traffic conditions in 1924, divided as follows: Maintenance of present roads, $1,250,000; completion of work already initiated and maintenance after completion, $1,420,000; projects approved but on which no construction has been undertaken, $2,780,000, and projects which will assume importance as other roads are constructed, $1,800,000.

It is suggested that this fund could be expended to the great advantage of the industries of the territory, and the cost of the work could well be borne by those industries if an equitable system of payment by each of the beneficiaries could be devised. The maximum sum to be expended in any one year would be less than the total saving for 1912 on freight costs due to roads already constructed.

According to the report, the benefits thus far derived make a strong case for the advocates of a larger appropriation. Data in the office of the commission show the cost of transporting freight and supplies during the year over the new roads at the prevailing rates to have been $1,243,735. It is estimated that the cost at the previous rates would have been $3,385,412—a saving of $2,141,677, which compares favorably with the total amount expended on the improvements. Moreover, this saving does not take into account the increased travel made possible.

Mining interests have also felt the benefits of the roads. Over a short stretch in the Nome district 15,000 tons of ore passed during 1912, representing a saving to the shipper of $75,000. This road, it is stated, paid for itself nearly eight times in six years.

Although the board makes no pretense of having built roads adapted for automobile traffic, machines are used under the ordinary summer conditions about Juneau, Fairbanks, and Nome. Several trips were made with machines during the past summer from Fairbanks to Chitina and to the coast at Valdez. The road commission placed a field truck of ¾-ton capacity on this road during the latter part of the summer and fall for the purpose of trying out the machine for supply and maintenance work and to test the availability of the road for such travel. The truck left Valdez 1.30 p.m. July 28 and arrived at Fairbanks 10 a.m. Aug. 6; left Fairbanks 12.30 p.m. Aug. 9 and arrived at Chitina about 5 p.m. Aug. 15; left Chitina late afternoon of Aug. 16, returned as far as Gulkana, thence back to Valdez, arriving 4.30 p.m. Aug. 19. The distance covered was 922 miles, making about 50 miles per day. The car while running averaged between 8 and 9 miles an hour.

A ROPE railway 75 miles in length will be built in India. It will connect the rich country in the vale of Kashmir with the plains of the Punjab over the Himalayas. The line, it is claimed, will be the longest in the world, the present longest being 22 miles and located in Argentina. Sections will be 5 miles long and most of the spans will be 2,400 ft. The steel towers, some of which will be 100 ft. high, will be braced, and double 1½-in. cables, 9 ft. apart, will carry the steel cars. The carrying capacity of these cars will be about 400 lb. The estimated cost is $1,600,000.

Alberta Central Railway

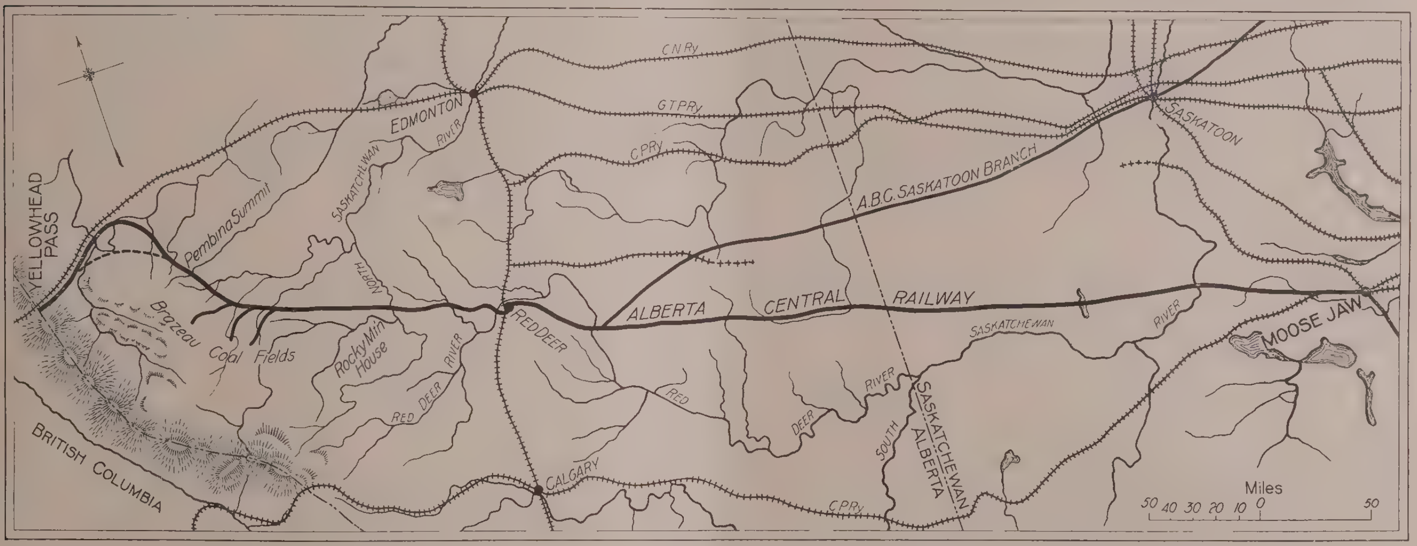
Account of Its Inception and Strategic Location and of the Methods Employed in Making the Reconnoissance Surveys

By J. GRANT MACGREGOR

Chief Engineeer, Alberta Central Railway, Red Deer, Alberta

OPPORTUNITY to open up a large tract of fertile prairie land, give access to the Brazeau coal fields and ultimately form a link in a new transcontinental railway was the germ in the idea of the Alberta Central Railway, construction on which was begun in 1910. Upon its locating engineer rested the responsibility of choosing a route that would allow at once a low first cost and later economical reduction of grades to the requirements of a trunk line. The reconnoissance surveys to find this route are believed to be of interest and are described in some detail.

The charter of the Alberta Central Railway was granted by the Dominion Government in 1901, and, with subsequent amendments, provided for a line from Moose Jaw, Sask., to the Yellowhead Pass on the boundary line between the Province of Alberta and British Columbia, a distance of approximately 700 miles. It stipulated as an intermediate objective point the town of Red Deer, Alta., and provided for a branch running to Saskatoon in a northeasterly direction from a point on the main line 100 miles east of Red Deer. An act of amendment in 1911 embraced extensions from Saskatoon to Hudson Bay, Moose Jaw southerly to the international boundary, and several minor branches to the Brazeau coal fields.



Map of Alberta Central Railway and Surrounding Territory between Moose Jaw and Yellowhead Pass

ADVANTAGES OF LINE

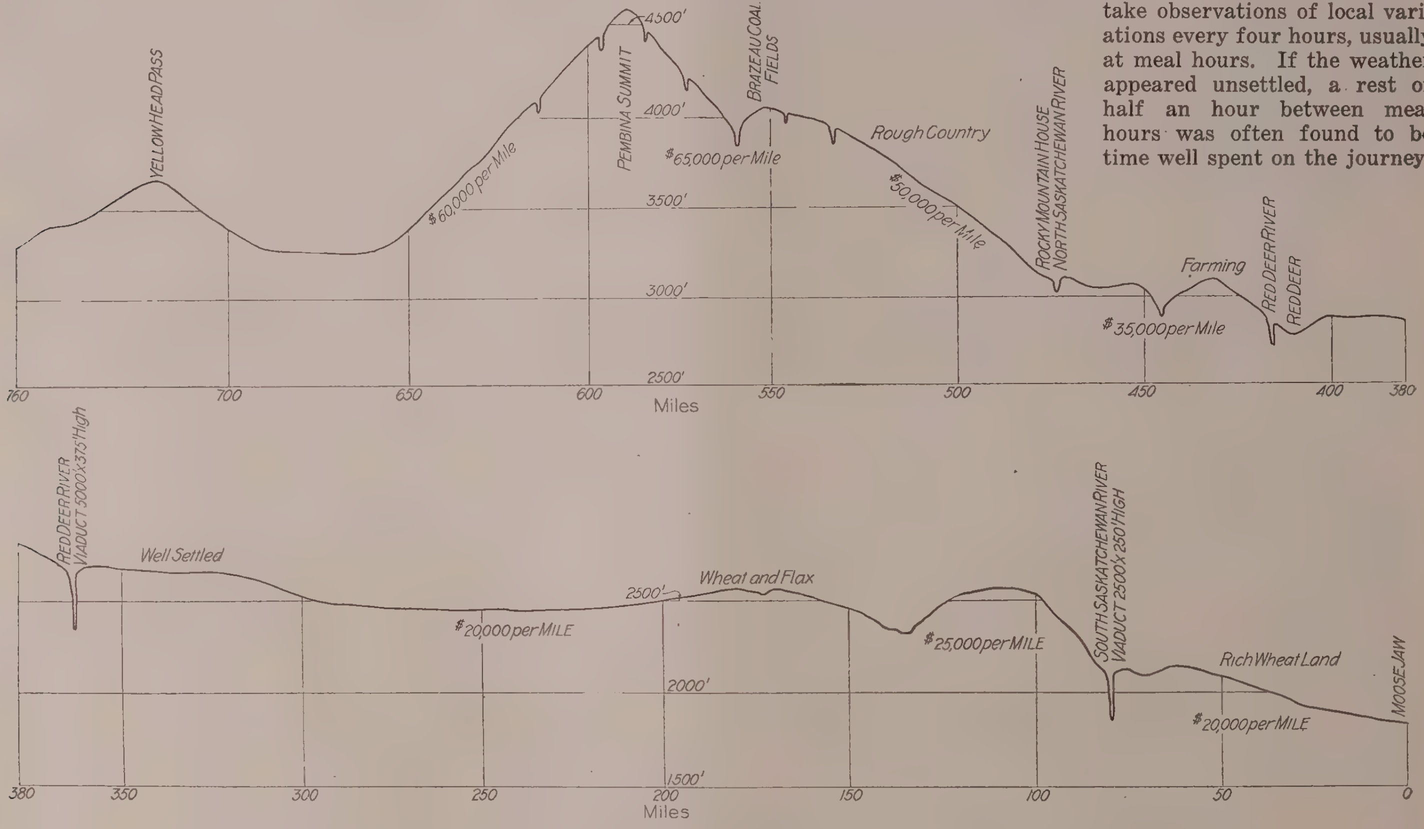
A glance at the map will at once show the tremendous advantages to be expected of a line so located, on account of the extent and exclusiveness of the territory to be served. In this, however, the anticipations of the original promoters were doomed to disappointment, for no sooner had surveys been made and plans filed than two more companies were in the field with plans for divergent routes across the same territory. The competitive companies referred to being stronger organizations, with greater interests at stake, followed up their surveys with their construction forces, and in a comparatively short time were in indisputable possession of their respective routes. Considering, however, that there is a zone of country from 50 to 100 miles wide tributary to those lines, much valuable territory still remains to be served by the Alberta Central Railway. The country referred to lies east of the town of Red Deer, principally between the Red Deer and South Saskatchewan Rivers. It is remarkable that although this region consists of a very large portion of the most fertile prairie land in the Provinces of Saskatchewan and Alberta its invasion by railways is of comparatively recent origin. Many conflicting reports were in existence with regard to its character until the first survey was made for railway purposes. Experienced pioneers from the Dakotas, Montana and Washington proved the fallacy of previous reports by settling themselves comfortably on the land long before the advent of the railways—believing faithfully that their solitude would not remain long undisturbed.

The country lying to the west of Red Deer as far as the foothills is of a very different character, and may be described as beginning with park prairie country, bordering on the pairie country above described, and gradually increasing in diversity of contour and density of vegetation until it mingles with the virgin forests of the foothills. The soil is a rich black loam affording abundant moisture and luxuriant grass—ideal conditions for the mixed farmer and rancher.

RECONNOISSANCE

As the work of reconnoissance involved the determination of the resources and possibilities of the country as a revenue producer, in addition to the usual surveys for the determination of its physical character, the foregoing introductory remarks as to its general character may not be devoid of interest. Where lines are projected in regions the resources of which are more or less unknown it is important that the work of reconnoissance should be of the twofold character mentioned. This article is designed to deal principally with the work of reconnoissance and location.

In August, 1909, the writer was authorized to investigate the possibilities of a direct line from Moose Jaw to the Yellowhead Pass. The advantage of a direct line between the points mentioned suggested to the original promoters another link in the transcontinental lines of the Dominion, and special emphasis was laid on the request that whatever was done in the way of reconnoissance the ultimate object would be the location of a line with low grades, the maximum to be 0.4 per cent in both directions. At the same time it was generally understood that for the present the Alberta Central could be no more than a colonization railway, the feature of low grades being only admissible where the cost would compare favorably with that of similar railways or branch lines built for colonization purposes.



Reconnoissance Profile, Showing Main Characteristics and Estimated Unit Costs for Various Sections

CHARACTER OF GROUND

Between Moose Jaw and Red Deer no difficulty was experienced in finding low enough summits to admit of a 0.4-per cent ruling grade in each direction with a reasonable amount of surface development to secure sustaining ground for a moderately cheap line, but from Red Deer to the mountains many long detours were necessary to attain this purpose. In the latter case it is evident that in endeavoring to obtain the shortest possible routes the topography will invariably develop long stretches of maximum grades. The question as to what extent distance should be sacrificed in order to avoid this so-called objectionable feature necessarily involves one or more of the intricate problems of railway location, and in order to provide for this during the work of reconnoissance sufficient margin was left for the locating engineer to work out the economic equations dependent thereon. The possibility of introducing velocity grades at favorable points during location was also considered. These were the governing features of the work of reconnoissance as carried out, but nevertheless the application of so extremely low a ruling grade was often found to be difficult and uneconomical.

The work in the field was facilitated by reference to the township maps and section corners. A straight line was drawn between objective points on the map and a zone of country 3 miles wide on each side of this line laid off to indicate the extreme limits of deviation. Next to grades in importance were to be considered the instructions relative to directness of route, but it was considered by the writer that a route which did not vary much more than 3 miles on each side of a "crow-fly" line would in a distance of 300 or 400 miles be considered fairly if not unusually direct, even on the prairies.

To those familiar with the use of the aneroid, with its contingent variations and vagaries, and the vigilance necessary to avoid errors in the field, the writer's experience may be of more than ordinary interest. The instruments used were one 4½-in. compensated surveying aneroid, reading to 8000 ft. for stationary reading, and two 3-in. field aneroids reading to 15,000 ft. After carefully considering the advantage of stationary readings and self-recording aneroids for correcting the error due to atmospheric conditions the writer was induced to abandon these methods and adopt a method by which a vigilant observer can ascertain the correction for atmospheric changes to better advantage in the field. Two instruments were in use in the field, one for observing the altitudes and the other in reserve in case of emergency and for detecting errors of a physical character in the instruments in use.

One day's work will suffice to illustrate the method of recording the observations and corrections made for determining the altitude. A start is made at some point the altitude of which, above sea level, is already known and carefully recorded by the aneroid a few hours before starting. Another observation is made by the same instrument at the same spot when starting, the difference of the two readings giving any local variation. The practice was to take observations of local variations every four hours, usually at meal hours. If the weather appeared unsettled, a rest of half an hour between meal hours was often found to be time well spent on the journey. Observations were always made on retiring at night, on rising in the morning, on starting out for the day and on arriving at the next camping place in the evening.

RECORD OF OBSERVATIONS

The accompanying blank form will illustrate the system used for recording aneroid observations in the field book and afterward reducing them to sea level. By carefully studying the fluctuations of the barometer during the day the corrections for each observation were determined by interpolation and entered in the column for "Corrected barometric readings." The difference between the corrected reading and sea level, which was determined at the start, or wherever available during the progress of the work, was added or sub-

RECORD OF RECONNOISSANCE OBSERVATIONS AND CALCULATIONS

Date	Hour	Field barometer reading	Elevation above sea level	Corrected barometric reading	Stationary barometer (if any)	Location and remarks

tracted, as the case might be, and the result entered in the column for "Elevations above sea level." The condensed profiles which accompanied the reconnoissance reports were afterward prepared from the elevations above sea level. These profiles pieced together form the continuous profile accompanying this article and cover a distance of more than 700 miles.

The accuracy of work was amply proved to be satisfactory for the purpose of a reconnoissance. The country from Red Deer eastward 200 miles was explored from Red Deer and checked on the return journey. The country from Moose Jaw westward 250 miles was covered by a single trip from the Moose Jaw end, making connection with the work from Red Deer eastward near Sounding Creek. On comparing the reading with sea level after a trip of 250 miles the error was found to be not more than 20 ft. Of course, this does not indicate that the error throughout the work was not at any time more than 20 ft. It would be more reasonable to suppose that in such a long distance, without a check, errors would compensate for errors, but at any rate the result is sufficient to show that accurate work can be done by the method explained. It may be added that the weather was extremely favorable for barometric observations.

The work of reconnoissance west of Red Deer was more tedious, particularly in the unsurveyed territory west of Rocky Mountain House. Several long journeys were made ahead of the preliminary survey party to define certain summits, but except for these occasional trips the reconnoissance engineer kept in touch daily with the preliminary survey party—which is, after all, the only satisfactory way of doing the work in rough country if preliminary surveys are already authorized.

BEGINNING OF CONSTRUCTION

It might be mentioned that the preliminary survey immediately followed the work of reconnoissance, and construction, which was begun in August, 1910, was well advanced before the preliminary-survey party was withdrawn from the field. Altogether 400 miles of line were located, about equally divided east and west of Red Deer. Plans and profiles of this location have been filed and approved by the Board of Railway Commissioners, giving the Alberta Central Railway Company access to the Brazeau coal fields on the one hand and the fertile prairies of central Alberta on the other, with a prospect of a through line to the coast, in which event considerable traffic would be developed in both directions.

Little of interest remains to be said with regard to the location which followed the reconnoissance, except that deviations from the route mapped out for the locating engineer were slight and consisted of more or less surface development for the purpose of gaining sustaining ground or distance. In one instance only in the rolling prairie country the locating engineer made a slight deviation, expecting to find better sustaining ground, only to return to the route mapped out after many weary miles of useless work. An important part of the work of preliminary location, however, was that of the topographer, upon whose work at the close of each day the locating engineer depended for the final adjustment of the located line to the contour of the ground. The value of accurate topographical work can hardly be overestimated, although seldom fully appreciated in the work of railway location.

Another feature, and by no means the least important, is the type of profile developed and the economic value of this location in country which is obviously hostile to a 0.4 per cent grade. On the long stretches of maximum grade referred to in a previous paragraph heavy cuts and fills were unavoidable, and looked almost forbidding, and would only be justifiable when the volume of traffic reached an average of twelve trains per day operated as a through line. The line located will, therefore, in course of time, it is assumed, admit of grade reduction to this extent without abandoning right-of-way, bridges or townsites. The maximum grade for present requirements was fixed at 0.8 per cent. The application of an 0.8 per cent maximum grade to the profile of a 0.4 per cent location will eliminate nearly all of the heavy work, and in many instances leave a mere surface line for present construction.

Repairing a Teredo-Eaten Bridge Pier Foundation

Old Grillage Protected by Concrete, Grout and Heavy Mat of Riprap

RAVAGES of the teredo caused the failure of a bridge pier at Fall River, Mass., by weakening the wooden foundation piles under the timber grillage at a depth of 45 ft. below the surface of the water. Repairs were recently made by forcing broken stone, concrete and grout under and around the old grillage and protecting it with a heavy mat of riprap. The methods employed were described recently in a paper entitled "The Fall River Bridge," presented to the Boston Society of Civil Engineers by J. W. Rollins.

ORIGINAL CONSTRUCTION

The Brightman Street highway bridge over the Taunton Great River at Fall River, Mass., has seven concrete piers and abutments, five of which were built on timber grillages supported on wooden foundation piles. Detachable cofferdam sides were assembled on the grillages, thus making watertight open caissons, which were floated to position and sunk to bearing on the pile tops by the masonry built in them. After the completion of the masonry above water line the sides were removed.

As it was known that the teredo abounds in the water at Fall River, the engineer recommended the protection of this foundation by an inclosing mass of riprap. It is stated by the U. S. Department of Agriculture, in a Forest Service bulletin entitled "Preservation of Piling Against Marine Wood Borers," that the teredo "seldom works to a depth of more than 30 ft., and that its worst attack is in very salty, warm, clear water." As the water here is polluted by sewage and is not very clear or warm, it was decided that the danger from the teredo at this depth might be negligible and the riprapping was omitted.

INJURY TO PIER

Work on the bridge was commenced in December, 1906, and in July, 1911, it was reported that pier 4 had settled 2 ft. at one end, 8½ in. at the other end, and had moved 12 in. longitudinally and inclined 5 in. from the vertical. It was assumed that the foundation piles driven to hard stratum had been broken and crippled, allowing the settlement, and an examination by divers showed that the gravel or broken stone filling around the tops of the piles had, in part, been scoured away to a depth of 2 or 3 ft., leaving pile tops exposed, and that some of the piles had been eaten almost entirely away by teredos down to the surface of the ground, weakening them so much as to be chiefly responsible for the failure of the pier. The investigation indicated that the pier was resting on the crippled piles and on solid stratum; and as careful observations showed no further settlement, plans were made for restoring the bridge to traffic and repairing the pier.

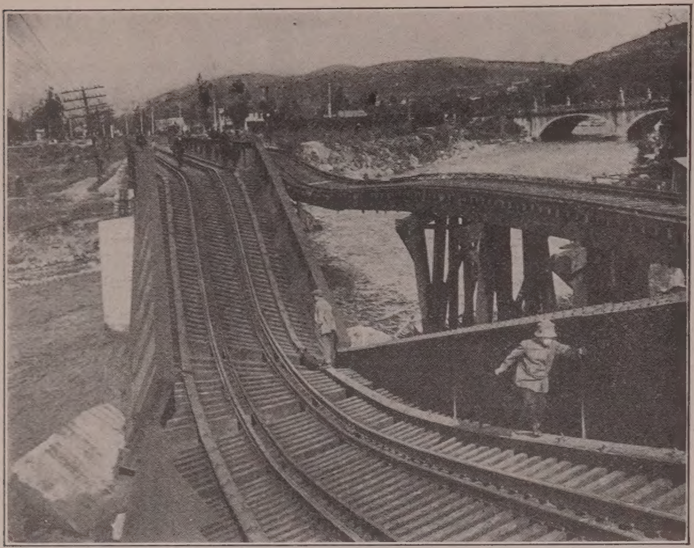
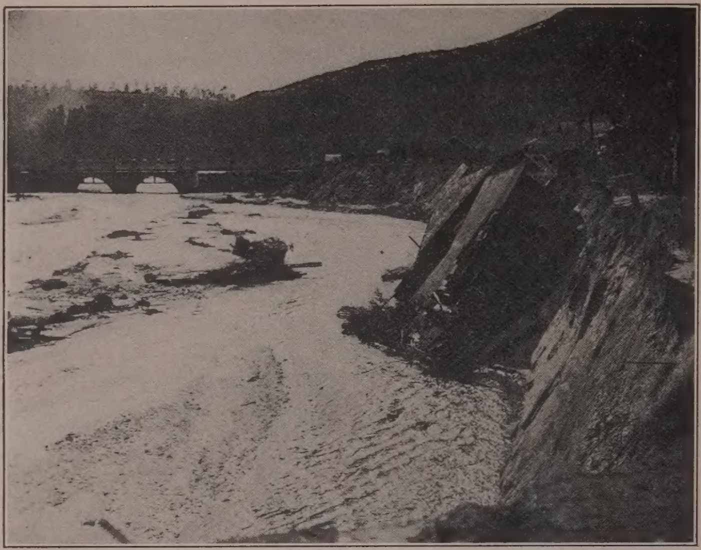
AUXILIARY SUPPORT OF SUPERSTRUCTURE

As the pier did not afford either strength or space for jacking the 900,000-lb. superstructure on it into position, a falsework tower was built under one of the spans at the nearest panel point to the pier and the trusses were supported on it during the repairs to the pier and for a number of weeks previous to that while arrangements were made regarding the authority necessary for executing the work. Each truss was supported on twenty-four yellow-pine piles 60 ft. long, driven to hardpan through 40 ft. of water by a hammer working in leads hung from the top chords of the trusses—an operation that proved to be slow and difficult.

METHOD OF UNDERPINNING

Underpinning was commenced by depositing crushed stone around the foundation and placing it by a diver as far under the grillage as possible, thus forming a temporary support on the hard stratum which showed no evidences of silt. After this was accomplished a timber form, 10 ft. wider than the grillage, was made with vertical walls 8 ft. high and attached to the lower end of an X-braced vertical framework about 50 ft. high. The lower edge of the form was provided with an 18 x ¾-in. steel cutting edge plate and the form loaded with rails and sunk concentric with the pier, the cutting edge penetrating the broken stone or river bottom enough to be secure. The form was rigidly secured in place by struts against the grillage and by turnbuckle rods opposed to the struts, and adjusted by divers.

A number of 6-in. wrought-iron horizontal water pipes, 6 ft. long, were placed between the crippled piles under the grillage and connected at their outer ends with vertical pipes 8 ft. long. A set of grout pipes 2 in. in diameter were also similarly placed. The outside of the form was inclosed and protected by riprap and crushed stone reaching to its top, and the interior of the form was filled with wet 1:2:3 concrete deposited through 8-in. tremies filled from the bridge floor. This concrete was brought up above the top of the grillage, entirely inclosing it and penetrating underneath it. After it had set a rich concrete made with 1-in. pebbles, sand and cement was forced into the 6-in. pipes, the whole mass being finally solidified by forcing grout under 100-lb. pressure through the 2-in. pipes. Finally the new footing and the base of the pier were inclosed by a large mass of protecting riprap, piled up highest on the weak side. The work on this pier was executed without profit to the contractor at a cost of about $25,000, which was eventually paid by the State.

Views Along Arroyo Seco, Showing Damage to Santa Fé Railway Bridge and Washout of House

January Floods in California

Damage to Property Largely Offset by Benefit to Crops Because of Increased Rainfall

HEAVY precipitation was general along the Western seaboard of the United States during the month of January. The storms were pretty thoroughly distributed over the State. A comparison of the precipitation for January, 1914, with the normal for the month shows it to be four times the normal in many instances. While the heaviest monthly precipitation occurred in the periodically wet district of Lake, Mendocino and Humboldt Counties, the heaviest twenty-four-hour rainfall, as a rule, fell in Southern California, the land of little rain. When one considers that the month of December was very wet, that the precipitation during January was extremely heavy and prolonged, and that when the ground was thoroughly soaked and streams all running full a rainfall of from 7 to 8 in. occurred in twenty-four hours it is not surprising that heavy floods resulted in the arid southwest. The runoff is rapid in the coastal streams, as they are relatively short in length and have very steep slopes.

Except for the coastal streams and the Kings River, and possibly the Tule River, high-stage records were not reached on the California streams. The gage height on the Kings River reached a maximum of 21.8, while the previous recorded maximum was 15.8. The flood from the Kings River is again pouring into Lake Tulare, a condition which has not occurred in many years.

None of the tributaries of the Sacramento reached the record stages of 1907 and 1909. The flood of March, 1907, was one of extremely high stages but of comparatively short duration. The flood of January, 1914, in the Sacramento, while of relatively low stages, was of extremely long duration, so that the total discharge during flood stages may reach or exceed that of 1907.

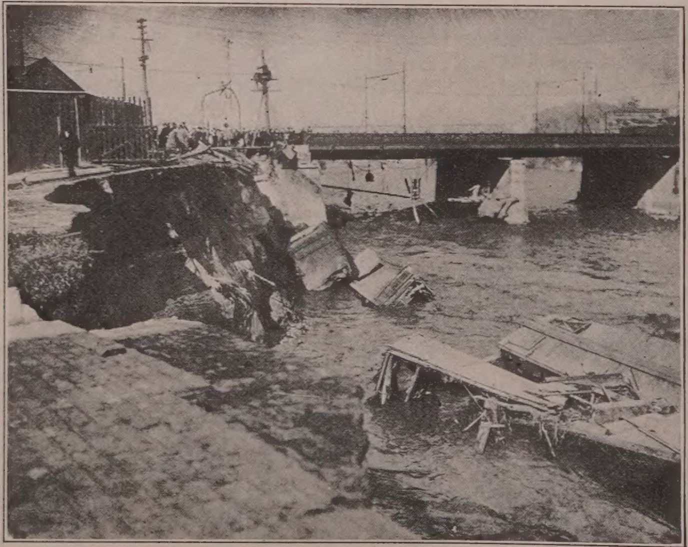
DAMAGES AND FLOOD LOSSES

Conservative estimates of the flood damages throughout the State, according to newspaper accounts, reach a total of about $5,000,000. Of this the loss in Southern California was estimated at $1,000,000. Santa Barbara and Ventura Counties were relatively heavy sufferers, the damages in the former county being about $500,000 and in the latter, $200,000. Railroads probably suffered most, though a preliminary estimate for the Southern Pacific, which has by far the greatest mileage in the State, fixes its damages at $200,000. The principal losses to the Southern Pacific were for bridges and embankment washed away and for delays in traffic.

This railroad had 300 ft. of steel bridge washed away on the Salinas River near Nacimiento; ¼ mile of embankment eroded near Harlem, which necessitated the construction of a new line along the bluffs; the bridge and roadbed near Ventura were considerably damaged. A severe washout occurred near El Monte, southeasterly from Los Angeles, and other washouts were on the Nordhoff branch, 15 miles in length from Ventura to Nordhoff. These are the heaviest damages on the Southern Pacific. Numerous smaller washouts occurred in many places, but these were quickly repaired.

This is an era of highway construction throughout the State, and the roads in process of construction were badly damaged. Reclaimed lands in the Sacramento and San Joaquin Valleys have, in most cases, come through the period of high water in excellent shape. One or two of the districts in the delta region were inundated from the failure of levees. The levees which failed had, in general, not yet been completed to the full section contemplated.

In general, though, it is felt throughout the State that the flood losses were small compared to the benefits conferred by the abundant rainfall. Bounteous crops and a prosperous year are assured and the farmers are rejoicing.



Los Angeles River with Banks Scoured by Flood and Bed Clogged with Broken Freight Cars

Book Reviews

The Directory of Cement, Gypsum and Lime Manufacturers for 1914 has been issued. This little book which now appears in its eighth edition, has 214 pages and flexible leather covers; its size is 3 x 5 in., and it has been equipped with a thumb index. Its purpose is to present a complete list of manufacturers of cement, gypsum and lime, enabling purchasers quickly to locate the nearest mill. The contents are divided into four main parts—cement, gypsum, lime and buyers' guide. The first part is subdivided as follows: List of cement companies in the United States and Canada; list of mills; alphabetical list of officers, superintendents, and chemists of cement companies, and list of brands of cement on the market, with trade marks in colors. One chapter deals with the annual output of cement, gypsum and lime for the past ten years, and another gives the list of officers of the associations of lime and Portland cement manufacturers. The directory is published by the Directory of Cement, Gypsum and Lime Manufacturers, 1207 Morton Building, Chicago. The price is $1 postpaid.

THE THEORY OF THE FLEXURE AND STRENGTH OF RECTANGULAR FLAT PLATES APPLIED TO REINFORCED-CONCRETE FLOOR SLABS. By Henry T. Eddy, Ph.D., Sc.D. Cloth, 6 x 9 in.; 104 pages, 25 illustrations. Minneapolis, Rogers & Company. $5.

(Reviewed by Frank H. Constant, Professor of Structural Engineering, University of Wisconsin.)

This volume of about 105 pages is of great interest, since it gives for the first time a fairly close rational method for determining the stresses in the type of flat slab known as the "mushroom" system. It is not possible in a short article to review the mathematical processes. The author makes a distinction between apparent and true bending moments. The former are the usual moments found from the principles of statics whenever the beam theory is applied to the slab problem; the latter, on the other hand, are those resulting from the actual stresses in the steel as determined by its elongation and expressed mathematically by equations in the form, $Ee_1 = p_1 - Kp_2$, where p_1 and p_2 are the external or applied longitudinal and lateral stresses, K is Poisson's ratio of lateral contraction to linear elongation, and Ee_1 is the true longitudinal stress. These equations are easily convertible into similar ones giving a like relation between apparent and true moments. Herein lies the essential difference between the solution here obtained and that resulting from the usual attempt to apply the beam theory to this form of slab. The author, by perfectly rational and mathematically correct steps, finally obtains a partial differential equation of the fourth order, from which he is able to find a solution which fits the conditions here at hand, of the form

$$48\,EIz = q\,(1 - K^2)\,[(a^2 - x^2)^2 + (b^2 - y^2)^2] \qquad (21)$$

where the origin is at the center of the slab, x and y are measured parallel to the sides of the panel, q is the load per unit area, and z is the deflection at the point $x\,y$. By further transformations simple equations are obtained for M and f_s, the true bending moments and steel unit stresses at any desired points in the slab. The points selected for comparison are the mid-point in the side belt, the center of the slab, the edge of the capital of the column, and the center of the column. Expressions for the deflection, z, at all of these points are also derived and tested numerically.

It is noted above (equation 21) that Poisson's ratio plays an important part, $(1-K^2)$ becoming a factor of the whole expression. Dr. Eddy, with the results of many actual tests upon this form of slab before him, determined the value of K to be approximately 0.5. He states that this value only holds for this form of slab and may not apply to some other form, nor to concrete more than two to four months old. The reviewer does not know of any direct measurements of K in slab tests which verify this value, nor does he find the author's explanation for the adoption of this value of K, on page 12, at all convincing. This explanation is reproduced in Dr. Eddy's discussion (Proc. Am. Soc. C. E., Aug., 1913) of the paper of Mr. John R. Nichols upon the "Statical Limitations upon the Steel Requirement in Reinforced Concrete Flat Slab Floors."

If K is not equal to 0.5, then $(1 - K^2)$ becomes, to a certain extent, the empirical constant, based upon many tests. However, this does not necessarily affect the correctness of the rational form of the equations determining M, f_s and z, for they all likewise contain I, one factor of which is ΣA, the equivalent steel area which can be assumed to be effective in the several parts of the slab. If A_1 is the area of cross-section of all of the rods in one side belt, and A_2 is a similar area for the diagonal belt, because of the criss-crossing of the several belts, especially over the column head, and the consequent irregular distribution of the steel, a very wide latitude for judgment exists in the choice of the effective area.

The author's selection for values of ΣA ranges from 1.5 A_1 for the mid-point of the side belt, to about 7.5 A_1 for the mushroom head. In the factor $(1 - K^2)/I$ any inaccuracy in the $(1 - K^2)$ may be balanced in the ΣA (contained in I). That is, if K be taken too great, making $(1 - K^2)$ too small, it is likely that ΣA has also been assumed too small. Thus, decreasing K from 0.5 to, say, 0.3 (the value for steel), or even 0.1 (the value for concrete), increases $(1 - K^2)$ from 0.75 to 0.91 and 0.99, respectively. The assumptions made for ΣA may easily be in error from 17 to 24 per cent. Moreover, the term d_1, the effective depth (usually designated by jd), also appears in I, and the values assumed, especially where there are several layers of rods, may be regarded as more or less approximate. In a word, $(1 - K^2)/I$ may be regarded as the empirical constant whose total value has been accurately fixed for this particular type of construction by a great many tests.

The author's endeavors to show a practical agreement between his rational formulas and the empirical ones of the inventor of the system are open to some criticism. Thus it is not clear how the true moment at the mid-point of the side belt, $M_1 = WL/128$ on page 26, can be transformed into $WL/192$ on page 27, Turner's formula being $WL/200$. Again, in the study of deflections (pages 44 and 45), the values on the right side of the numerical inequalities (65) are incorrect, finally effecting a disagreement between the author's formula (71) for the deflection of the center of the panel below the edge of the cap, and Turner's, of about 20 per cent instead of 10 per cent.

However, the checking of the author's formulas with Mr. Turner's may be considered incidental to the main purpose of the book (they should be expected to be in fairly close agreement, since they were both based upon the same tests). Tests made since the publication of the book additionally confirm the reliability of the author's results.

It will be asked whether the methods of the book will apply to other forms of flat slab construction. The differential equation (20) possesses a wide generality of application and its special solution (21) will doubtless apply to all uniformly loaded rectangular (nearly square) panels where the four corners are clamped to remain horizontal over the column head, whatever the nature of the steel distribution. In fact, up to equation (20) the steel was assumed to be replaced by a thin sheet of metal of equal weight, and the particular direction in which the rods ran was of no importance. However, if $(1 - K^2)/I$ is to be thought of as a factor whose correct values can only be verified by tests, the final working equations are here of value only for the mushroom system. Even slight changes from the standard mushroom design, as the author himself states, would involve considerable changes in the values of ΣA. For some other system of slab-bracing the correct values to assign to K, $j\,d$ and ΣA would have to be refound by tests upon that particular slab.

The maximum stress in the steel is found to occur at the middle of the side belt; that in the concrete at the column head.

The theoretical part of the book is followed by a number of sample computations, with the author's running commentary, which are valuable in fixing the exact meaning and denomination of all the terms. Section 17 is devoted to a detailed comparative test of the Turner mushroom slab with the Norcross slab. C. A. P. Turner wrote the preface, Section 18, giving suggestions regarding the construction and finish of floor slabs, and the appendix, containing a standard specification for reinforced concrete floors.

MACHINERY'S HANDBOOK. Compiled by Erick Oberg and Franklin D. Jones. Leather, 4¾ x 7¼ in.; 1400 pages. New York, The Industrial Press. $5 net.

This handbook presents data of sufficient scope to cover the useful arts of machine design, construction and operation as used by the mechanical engineer, draftsman, shop superintendent, toolmaker and machinist. The compilers have used for much of their data selected material especially accumulated for this purpose by "Machinery." In addition, use has been made of new material here published for the first time. The reviewer notes that particular consideration has been given to the presentation of the subject matter. This is peculiarly noticeable in the attractive and convenient form of presenting the mathematical tables and formulæ. Selected examples completely solved help the unpractised man in their use without in any way distracting those familiar with the use of formulæ. Among the subjects especially well treated the reviewer notes those of strength of materials; springs, spur, bevel, spiral and worm gears; screw thread systems, horsepower for machine tools and the heat treatment of steels. The handbook is valuable both for the engineer and for the practical man for reference in the office or the works.

Letters to the Editor

Rapid Progress on St. Louis Intake Tunnel

SIR: Regarding my brief article in your issue of March 7, page 281, giving the progress on the St. Louis waterworks tunnel which is now being driven under my charge, I would like to make a correction. The progress for the thirty-one days from Jan. 21 to Feb. 21, one calendar month, was 744.7 ft., including lost time, etc. I would prefer to have it appear that way instead of taking thirty-one working days, as that would not really be a month's work. The best week's progress was, as stated, 184 ft.; the best daily progress was 29.1 ft., and the best progress for one shift was 10.9 ft. The tunnel is circular and has to be driven to a pay line of 11 ft. diameter. Up to date the cross-sections show that the tunnel has been driven about 20 per cent under that line, including the loose muck left in the bottom to make room for two cars in the heading. When the latter is taken out the section as driven will be from 5 to 8 per cent inside the pay line.

St. Louis. C. H. HOLLINGSWORTH.

Good Streets for Financially Handicapped Communities

SIR: The matter of street improvement in many towns and villages is probably often delayed because the examination of costs of city streets, State highways, etc., ranging from $2 to $3 per square yard, gives rise to the thought that such improvement is possible only by making a tremendous expenditure of money. The following information is given to show that good streets are possible for almost any community, regardless of its financial condition.

Because of the belief that good streets were too expensive, the Borough of Columbia in 1911 probably had worse streets than many towns of its size (population 13,000). It has since learned, however, that improvements can be had without a burdensome debt. The annual appropriation which was to be used for maintaining and keeping clean its 326,600 sq. yd. of highways and for the building of new streets was $8000. Of this amount $1800 was spent on miscellaneous repairs and supplies, while the cost of removing ice and weeds and sweeping streets was $1950, or about ½ cent per square yard. In two years $8500 was spent in rebuilding 37,500 sq. yd. of street; 10,000 sq. yd. of macadam were improved at 8 cents per square yard, and $1882 was expended on the penetration method and vitrified blocks, while 25,000 sq. yd. of tar-coated macadam were constructed at a cost of 23 cents per square yard.

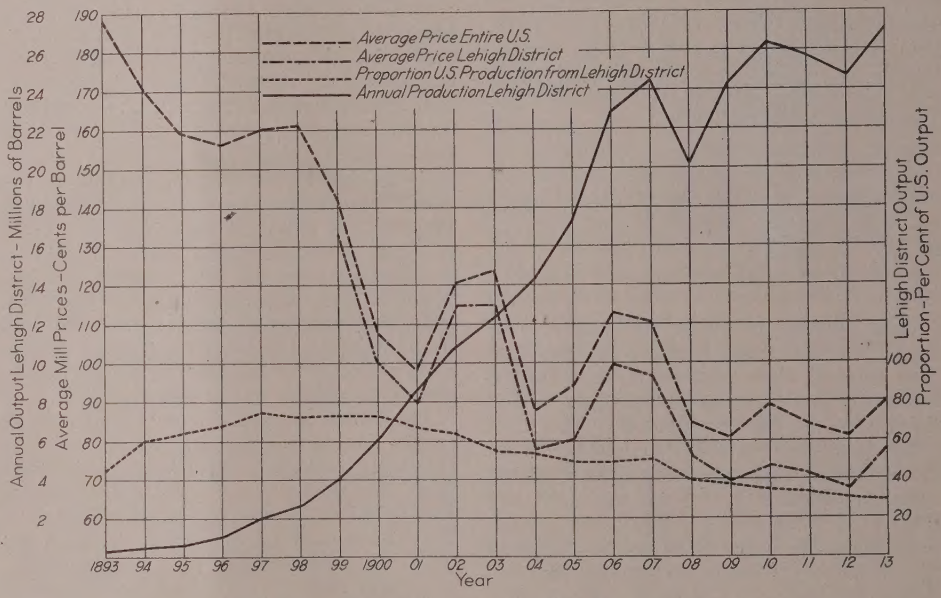
The tar-coated macadam, while inexpensive, is satisfactory in every way. In appearance it is similar to sheet asphalt. It is noiseless, dustless, mudless, gives good foothold to horses, withstands motor traffic, and has suffered the washings from tremendous rains without showing any ill effects. Maintenance consists of recoating spots through which the stones show, and ranges in cost, annually, from 2 cents per square yard in the heaviest-traveled districts to a fraction of a cent in the others.

In the writer's opinion the small towns and villages occupy an important place in the highway system of any section, and any encouragement toward giving them better streets and roads within their financial possibilities will tend toward increasing the mileage of improved highways of the State.

C. A. HOGENTOGLER,
Borough Engineer and Supervisor.
Columbia, Pa.

Output and Price of Cement in the Lehigh District

SIR: The general similarity of the price curve of cement to the same curve in the early history of the steel industry is suggestive. The periods of both high and low price have all been two years in length. Each period of high price has been followed by a new low record price. Each high point has been less than the preceding one, thus causing less effect on the general average price over a number of years; but the good years do not compensate for the poor ones.



Cement Production and Prices in Lehigh District, 1893-1913

The decline in price and the corresponding increase in output from 1890 to 1901 mark the introduction of the rotary kiln. The fact that there has been a steady increase in the output of the country as a whole seems very significant. The falling off in the Lehigh district in the years 1908, 1911 and 1912 was more than made up in the country as a whole. A large part of the demand in 1906 to 1908 was caused by the reconstruction in San Francisco after the fire and earthquake. The decreasing importance of the Lehigh district is partly to be expected as other plants are built in the South and West. The Hudson district is cutting severely into the New York and New England trade. The decrease in output of the Lehigh district shows that the home market has not been developed to a point where the output of the mills can be absorbed, as the outlying territory has been taken over by local plants.

The steady downward tendency of the average prices, more especially in the past few years, indicates that greater economies will have to be practised or the price maintained at a somewhat higher figure. The latter would be somewhat difficult to accomplish in an industry as competitive as the cement industry. It may be accomplished in good years when all the mills have plenty of orders, but when the demand falls off the price is bound to be cut in order to get a larger share of the market.

The price in the Lehigh district has been dropping away more and more from the average for the country.

H. V. SCHREIBER,
Managing Engineer, Sellers & Rippey,
Consulting Engineers.
Philadelphia.

Raid on Stock-Selling Engineering Company

SIR: Referring to your editorial on "Financial Engineering" in the issue of Feb. 14 and the news item on "Raid on Stock-Selling Engineering Company" in the Current News of the same issue, permit me to say that Theodore Rodmann seems to have transferred his activities to Chicago. On Feb. 15 I answered an advertisement for an engineering partner to invest $1,000 which appeared in the "Chicago Tribune" of the same date. Two letters signed by Mr. Rodmann were received asking me for a personal interview. The addresses given were Peoples Gas Building and Mallers Building. A similar advertisement appeared in the "Tribune" on March 1. I answered this and received an answer on stationery headed Flynt & Company, Inc., with headquarters in the Peoples Gas Building. The Mallers Building address was given as a branch office.

Having read your editorial, I laid the matter before the Post Office authorities, but they refused to act, saying that they could not proceed unless I had been swindled.

As there seems to be no way of reaching these people other than through publicity, I am giving you these facts so that other engineers may be warned in time.

Chicago. J. K. MOORE.

[Their attention having been called to the items in the Engineering Record and also to Mr. Moore's experience, the "Chicago Tribune" states that it will not knowingly take further advertisements from this company.—EDITOR.]